DOCUMENT RESUME

ED 322 873 IR 014 164

AUTHOR Flynn, John P.; And Others
TITLE Essentials of Evaluating Computer-Based Education in Higher Education.
INSTITUTION Western Michigan Univ., Kalmazoo. School of Social Work.
PUB DATE 89
NOTE 54p.; Field Studies in Research and Practice.
PUB TYPE Reports - Research/Technical (143) -- Tests/Evaluation Instruments (160)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS College Faculty; College Students; *Computer Assisted Instruction; *Evaluation Criteria; *Evaluation Methods; *Field Studies; Higher Education; Questionnaires
IDENTIFIERS Heermann (Barry)

ABSTRACT

The use of computers as an aid to instruction is increasing along with the amounts of time, effort, and resources needed to implement computer-based education (CBE) in higher education. The proliferation of instructional computer applications in the classroom necessitates the development of a system for evaluating CBE as it is used in the educational setting. Such a system, based on an extensive literature review and on the theoretical work of Heermann concerning learning objectives, intellectual skills, teaching styles, and mode of computer delivery, includes evaluative questions for both the instructor and the student user. Those for the instructor are developed around the following components: (1) environmental, including political, costs, motivation, and convenience; (2) instructional, including goals, content, format, and learning outcomes; and (3) managerial, including record keeping and author support and utilities. The student-user evaluation questionnaire for CBE consists of 50 scale items and 3 open ended questions. These instruments facilitate the evaluation not only of the use of CBE in higher education, but also of inherent value issues such as student control, creativity, and confidentiality. Both the instructor and student-user questionnaires are included, as well as a list of references and other readings. (DB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
X This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

ED322873

ESSENTIALS OF EVALUATING COMPUTER-BASED EDUCATION IN HIGHER EDUCATION

by

John P. Flynn, Ph.D.
Project Director

Nancy Aronson
Brian Brook
Charles Clearwater
Carolyn Eble
Ruth Eichler
Irene Hinkley
Catherine Hoeksema
Mary Hoekstra
Kathy Mulhern

Field Studies in Research and Practice
School of Social Work
Western Michigan University
Kalamazoo, Michigan

Spring 1989

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
John P. Flynn
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Copyright 1989 John P. Flynn, Western Michigan University, Kalamazoo, MI

IR014164

BEST COPY AVAILABLE

TABLE OF CONTENTS

EXECUTIVE SUMMARY iv

PREFACE vi

PROBLEM STATEMENT 1

METHODOLOGY 3

The Problem of Definitions 3
Organization of the Project 3
Uses and Functions of CBE: A Theoretical Framework 3
Learning Objectives 4
Intellectual Skills 4
Teaching and Learning Styles 5
Mode of Computer Delivery 5
Components of CBE: A Theoretical Framework 6
Criteria to be considered in CBE Evaluation 6
Construction of a Student Evaluation Instrument for CBE 7
Summary 7

LITERATURE REVIEW 9

Computer-Based Education in the Professional Environment 9

Major Milestones in Educational Computing 9
Computer Applications 10
Instruction 10
Tutorials 10
Drill and Practice 11
Instructional Games 11
Testing 12
Teaching Tools 12
Problem-Solving Systems 13
Expert Systems 13
Hypertext 14
Simulation 14
Management 15
Software Clearinghouses 16

The Efficacy of CBE as a Learning Device 16

Learning Outcomes 17
Attitudes Toward Instructional Quality and Course Content 18
Attitudes Toward Computers 19
Instructional Time 19
Implications for Future Studies of CBE Effectiveness 21

Evaluation Systems for Computer-Based Education 21

What is Evaluation? 21
Conceptual Models for Evaluation 22
Discrepancy Model 22
Stake's Model 22
The CIPP Model 22
Formative/Summative Model 22
Effort, Efficiency, & Effectiveness Model 23
Goal Model 23
Guidelines for Evaluating CBE 23
Instructional Component 23
Managerial Component 24
Environmental Component 25
Summary 26

FINDINGS AND RECOMMENDATIONS 27

The EIM Model for Evaluating CBE 27
Criteria to be Considered in CBE Evaluation 28
Student Evaluation Instrument for CBE 31
Recommendations 39
Policies 39
Procedures 40
Evaluative Data 40
Summary 40

IMPLICATIONS 41

REFERENCES 43

OTHER READINGS 47

ESSENTIALS OF EVALUATING

COMPUTER-BASED EDUCATION

IN HIGHER EDUCATION

EXECUTIVE SUMMARY

The use of computers as an aid to instruction has accelerated in higher education during the last decade. With the increased use of computers in the educational setting comes the need for a system to evaluate time, effort, and resources devoted to the development of instructional computer applications. Most importantly, an evaluation system will have to address the appropriateness and effectiveness of computer use in education.

This project team identified the essential components needed to evaluate computer-based education in higher education. The project team developed protocols for the collection of data for evaluation purposes and identified what should be evaluated.

To achieve its purpose the project group focused on an extensive literature review concentrated in three areas: a) computer-based education in the professional environment, b) the efficacy of computer-based education, and c) the evaluation of computer usage in an educational setting.

Over the course of the last thirty-plus years computer-based education has developed from simple reinforcement teaching aids to comprehensive standalone systems. Computers presently function both to complement traditional teaching and improve the effectiveness and efficiency of the educational system. Computer usage thrives at all levels of education: elementary, secondary, higher and special needs. Its applications range from remedial drills to word processing to expert systems.

As computer-based education grew and developed, the desire and need to understand the efficacy of including computers in an educational setting also grew. A great deal of research has been undertaken to answer this concern. From this wealth of data it has been ascertained that the use of computers in an educational setting produces consistently favorable and measurable outcomes in achievement, performance, and retention, in student attitudes toward instructional quality and course content, in student attitudes toward computers, and in instructional time.

As the use of computers has become increasingly prelavent in education, the need to develop a comprehensive and reliable evaluation system has become pressing. There are many different conceptual frameworks for conducting evaluation. This study was greatly aided by the conceptualizations of Barry Heermann (1988). Heermann categorizes computer functions in educational settings along four major categories: learning objectives, kinds of intellectual skills, teaching styles, and the mode of computer delivery. These categories operate within the parameters of other- versus self-directed learning and theoretical versus applied learning. The literature review suggested an additional and complementary framework formulated in the course of this project: the consideration of environmental issues relating to both process and management, instructional process and content, and the management of data pertinent to these processes. When joined together, these frameworks became a complete and solid structure, i.e., a comprehensive evaluation system.

This system enabled the project team to develop a new evaluation model designed to effectively meet the needs of computer-based education. This model is entitled the EIM--environmental, instructional, managerial---model. This system further provided for the development of evaluative instruments for both instructor and student use. These evaluation tools consist of: a) a list of 63 evaluation questions to assist the instructor or program developer, and b) a 53-item student user questionnaire.

A number of recommendations for computer-based education emerge from this project. These recommendations are intended as an aid to the instructor, both in establishing and evaluating computer-based education.

The use of computers in higher education is now a reality. Undoubtedly the debate will continue over whether the investment in computer-based education yields appropriate benefits. Evaluation can not only be a catalyst to objectify this debate, it can help identify and further understand the problems inherent in computer-based education.

School of Social Work
Western Michigan University
Kalamazoo, Michigan 49008

June, 1989

PREFACE

The following research project was completed as part of the required coursework in the graduate School of Social Work, Western Michigan University, Kalamazoo, Michigan. The course, Social Work 686, Field Studies in Research and Practice, occurred from May 1 through June 21, 1989. The course objective is to integrate theory, practice, and research skills in the social work context.

The staff consisted of Dr. John Flynn, Project Director, Nancy Aronson, Brian Brook, Charles Clearwater, Carolyn Eble, Ruth Eichler, Irene Hinkley, Catherine Hoeksema, Mary Hoekstra, and Kathy Mulhern, graduate social work students.

This project process has identified the essential components needed to evaluate computer-based education in higher education. The project team also developed protocols for the collection of data for evaluation purposes and determined what should be evaluated.

It was necessary to become acquainted with a wide range of information and literature in the 7 1/2 week period. The group reviewed the literature to determine the current use of computer-based education, its efficacy, and evaluation considerations. Other activities exploring state-of-the-art developments in the field were also pursued. These included: participating in a teleconference on innovative uses of hypermedia in education, visiting a software company specializing in voice recognition applications for the handicapped, experimenting with tutorial and simulation programs, using an expert system, and utilizing the word processor.

The reader should note that the citations provided at the end of this report consist of two parts. The "References" are those items used in the literature review and cited in the body of the report. Those citations are followed by other material listed under the title of "Other Readings."

The authors would like to call particular attention to those who offered significant support to the development of this project. Chen-Lin C. Kulik and James A. Kulik of the Center for Research on Learning and Teaching of The University of Michigan were most gracious in making their recent work on meta-analyses of the efficacy of computer-based education available to us in a timely manner. Barry Heermann's theoretical formulation in Teaching and Learning with Computers (1988) provided an essential foundation for much of our conceptualizations. On the local level, George Dennison, Provost of Western Michigan University, is acknowledged for his solid support of the instructional applications of computing. Much of that support is made real in the persons of Tom Gabriele, Director of the Academic Computer Center, and the Center's staff, and by Howard Poole, Director of the Office of Instructional Development, all colleagues and friends.

PROBLEM STATEMENT

The use of computers as an aid to instruction has accelerated in higher education during the last decade. In Academic Computing, a magazine devoted to computer use in higher education, Smallen (1989) indicates that infusing computing into the curriculum is an important issue in higher education. The task is to use computers in order to meet important educational goals. The ultimate purpose, of course, is to prepare students for the computerized world (National Commission for Employment Policy, 1986).

Western Michigan University (WMU) School of Social Work, as elsewhere in academia, encourages the use of computers in the instructional process. Computer instruction has been incorporated into the design of various courses in social policy, planning, and research. An increasing amount of professors' time is spent on the development of instruction by designing courses involving the use of computers. In addition, a project undertaken at WMU during the 1988-1989 academic year attempted to further infuse instructional uses of computers into the school curriculum by supporting individual and faculty development and through targeting specific content in selected courses for computer-based applications.

Other evidence indicates that more attention is being paid to infusing computing into the higher education environment at WMU. As professors incorporate the use of computers into the educational setting, the availability of computers to students has also increased. The University has a number of public laboratories and terminals available to students and faculty. A variety of machines--as terminals to the University's mainframe computer or as standalone microcomputers--are widely available. Both the Academic Computer Center and the Office of Instructional Development offer workshops for faculty, staff, and students on a regular basis. Some departments have been funded for developmental projects involving computer instruction. A new computing center is under construction. Finally, WMU has a discount purchase plan for faculty, staff, and students desiring to buy microcomputer software and hardware. The demand for computers and services is likely to grow as computer-based education increases at Western Michigan University.

With the increased use of computers in the educational setting comes the need for a system to evaluate the huge amounts of time, effort, and resources devoted to the development of instructional computer applications. How does one evaluate computer-based education in the university setting? To pursue this research question, this project group focused on the essentials for evaluating computer-based education in higher education.

METHODOLOGY

The Problem of Definitions

The purpose of this project was to determine the essential ingredients for evaluating computer-based education (CBE) in higher education. To achieve this purpose, it became necessary to unscramble the myriad of acronyms found in the literature. Through the process of the literature review and discussion of project goals, the group constructed a framework. The project members concluded that the essentials for an effective computer-based education (CBE) program fall into three separate, albeit interrelated, sets of functions. These are: a) the instructional process and content, b) the management of data pertaining to those processes, and c) consideration of the environmental issues relating to both process and management. The first of these, instructional process and content, is referred to in this report under the general rubric of computer-assisted instruction, or CAI. The second, the issue of management, is referred to throughout this report as computer-managed instruction, or CMI. The third element, the issue of environment, is referred to throughout as the computer support environment, or CSE. Taken together, these three elements (i.e., CAI, CMI, and CSE) comprise what is referred to inclusively as computer-based education, or CBE. In summary, these three elements are sometimes referred to as "instructional," "managerial," and "environmental," and are three aspects around which CBE is organized and delivered. CBE is, then, an umbrella concept describing the many ways computer technology is used for teaching and learning.

The main premise of the project was that it would be useful to effectively evaluate CBE instruction because of its increasing presence in higher education. To achieve this purpose, the project members focused on an extensive literature review concentrated in three areas: a) the prevalence of CBE in the professional environment, b) the efficacy of CBE, and c) evaluation of CBE in the educational setting.

Organization of the Project

In order to effectively make use of time and personnel, an exploratory research design was used. The time limitation of the project restricted the major source of data to the existing CBE literature. The group undertook an extensive literature review in the previously mentioned areas by dividing into three subgroups. Each sub-group was then assigned a topical area to research independently. Once this review was completed, each group created an outline that summarized the areas of importance found in their literature search and then wrote a section to be included in the final project report.

Uses and Functions of CBE: A Theoretical Framework

The theoretical framework for the study, and the section which follows, is in large part predicated on the work of Barry Heermann. His book, Teaching and Learning with Computers, (1988), is based on four categories: a) learning objectives, b) intellectual skills, c) teaching styles, and d) mode of computer delivery. These four categories are located along two dimensions: a) other- versus self-directed learning, and b) theoretical versus applied learning.

Learning Objectives

Heermann divides learning objectives into four types: a) knowing that, b) knowing how, c) knowing where, and d) knowing what and why.

The objective of "knowing that" is most likely to be achieved by other-directed, theoretical learning. An example of this would include knowing that George Washington was the first President of the United States. This sort of factual knowledge may also include principles, theories and concepts.

"Knowing how" is the result of applied learning. Because such learning is usually guided by an experienced person, it is also a form of other-directed learning. An example of this would be knowing how to debate the merits of an issue, such as racial integration in school, versus knowing that the Supreme Court ruled school segregation unconstitutional in 1954.

The learning objective of "knowing where" is self-directed, theoretical learning. This objective encompasses the locating and gathering of information from which theories and ideas might be extracted.

Heermann's final learning objectives, "knowing what and why", are examples of self-directed, applied learning. "Knowing what" is the ability to distinguish among different types of information and data. "Knowing why", though, means finding or exploring theoretical understanding or conceptual knowing.

Intellectual Skills

Intellectual skills is the second category discussed by Heermann. He states that, just as different kinds of knowledge can result from learning, different kinds of intellectual skills can be developed to acquire certain kinds of knowledge. Heermann categorizes intellectual skills into four types: a) informational, b) problem solving and integrational, c) investigative, and d) analytical. He defines informational skills as allowing the mastery of the factual information, principles, and theories important to a discipline or course of instruction. Use of these skills correlate with the learning objective of "knowing that". Informational skills are most often used in other-directed, theoretical learning.

The second type of intellectual skill, problem-solving and integrative, corresponds with the learning objective of "knowing how". Problem-solving skills allow a student to find the best outcome for situations in the real world or in simulations. Integrative skills allow a student to see relationships among individual things or among parts of a whole. These intellectual skills are also fundamental life skills that are the basic tools needed to acquire any kind of applied knowledge. Problem-solving and integrative skills are usually other-directed, applied learning.

Heermann's third skill type in this section is investigative skills. Use of these skills corresponds with the learning objective of "knowing where". These skills enable a student to locate and access information and ideas. These may be the opinion of peers, faculty members, or authorities in the field or information and ideas derived from a discipline's literature. Students often develop these theory-oriented skills during independent work. Investigative skills are self-directed, theoretical learning.

The final type of intellectual skill is analytical skill. Analytical skill is connected with the learning objective of "knowing what and why". These skills involve interpretation, evaluation, and examination of subject matter in order to arrive at basic or general truths or inductive

reasoning. Analytical skills are most often developed through self-directed, independent work in applied learning.

Teaching and Learning Styles

Teaching and learning styles are the third category in Heermann's four-part framework. These styles are of four types: a) teacher, b) facilitator, c) mentor, and d) broker.

The teacher disseminates factual information through highly structured lectures and reading assignments. The teacher stresses the learning objective of "knowing that", thereby allowing the student to respond by taking notes, studying text books or other reading assignments, or answering questions on exams--in other words, by using informational skills. Instructors who prefer this style are likely to emphasize theoretical learning and to desire firm control over their students.

As a facilitator, the instructor plans and closely monitors learning activities that directly involve students. If engaging in actual experience is not practical, simulations may be used. This corresponds with applied, self-directed learning or the learning objective of "knowing how". Also, the instructor emphasizes development of the problem-solving and integrative skills of their students in this approach.

The mentor organizes readings, group processes, and presentation of theory and principles in such a way that students choose the experiences they need to master the discipline at their own pace, on their own terms. This allows the student to practice their investigative skills and the learning objective of "knowing where". According to Heermann, the mentor is oriented toward students who enjoy self-directed, theoretical learning.

The final category under teaching styles is that of broker. The broker, like the mentor, encourages students to direct their own learning through independent study projects. The broker's orientation, however, is practical rather than theoretical. An instructor who prefers the broker teaching style will encourage students to develop analytical skills through self-directed, applied learning, with the learning objective of "knowing what and why."

Mode of Computer Delivery

This final category in Heermann's framework is comprised of four types: a) the computer as teaching machine, b) the computer as simulator, c) the computer as resource, and d) the computer as a tool. These labels characterize the uses of the computer in teaching and learning.

When looking at the computer as a teaching machine, The concern becomes basic factual or theoretical knowledge in a particular subject area. An example might be a CAI program that offers a drill in understanding basic social science research skills. The computer as teaching machine aids students in developing informational skills and achieving the learning objective of "knowing that". An instructor with the preferred teaching style of teacher might use this mode of delivery to supplement lectures and textbooks, letting the computer direct the students' learning just as the teacher does in the classroom. Consequently, this mode of delivery is other-directed, theoretical learning.

The second type of mode of delivery is using the computer as simulator. Here the computer promotes the development of problem-solving and integrative skills by allowing students to manipulate parts of a model of reality and observe the effects on the rest of the model. By allowing practice with realities not otherwise available for experimentation, the

computer as simulator helps students apply their learning and achieve the objective of knowing how. Also, the instructor with the preferred teaching style of facilitator might use computer simulations to supplement student learning, while keeping control over the learning environment with the use of applied learning.

The third type is using the computer as a resource. The computer acting as a resource connects the student with a network of people and/or data. It sharpens investigative skills by allowing students to find information in data bases or consult with peers, instructors, or experts. As a result, the students gain an understanding of theory and fulfill the learning objective of "knowing where". Here, an instructor with the preferred teaching style of mentor might have students consult each other when working on a group project. Students who are well organized, independent, and interested in finding out about the thoughts and experiences of others will benefit most from using the computer as a resource for self-directed, theoretical learning.

Heermann's final mode of delivery is using the computer as a tool. Students can use computers as tools in many kinds of learning tasks, but common tool programs, such as idea generators and spreadsheets, are particularly well suited to aid students in developing analytical skills. With the help of the computer, students working independently on practical problems can concentrate their time and energy on achieving the learning objective of "knowing what and why." Also, an instructor with the preferred teaching style of broker might use the computer as a tool to direct the student in learning about real-world situations. Students who are especially likely to benefit from using the computer as a tool are those who have considerable desire and ability to direct their own learning and who prefer using applied learning techniques.

Components of CBE: A Theoretical Framework

As noted above, the project team developed an additional framework derived from the many references to computer usage in education, such as CAI, CMI, etc. The group utilized the Heermann framework as a device to categorize or allocate the various applications of computers in teaching and learning and as a means of assessing appropriateness of application. In addition, the project team needed a framework to organize its review of the literature and to proceed with constructing a system for evaluating computer applications. Consequently, the three-part scheme of instructional, managerial, and environmental components discussed in the first part of this section also served as an organizing framework for the report of the literature review.

With CBE as the umbrella concept, the instructional considerations were organized under the concept of computer-assisted instruction, or CAI. This was defined as including what is taught and how it is taught. Computer-managed instruction (CMI) is defined here as the methods by which data is stored, manipulated and used in the course of operating a CBE system, such as for record-keeping, evaluative feedback, or scoring. Lastly, computer support environment refers to the many factors that are encountered by students, faculty, and the organization sponsoring CBE that either impede or assist computer based education.

Criteria to be Considered in CBE Evaluation

Once the literature review was completed, data generated by existing CBE mainframe and microcomputer materials at Western Michigan University were also examined. This included item analyses of tutorial materials, time on task by student users, rank order correlations comparing time on task with other measures of course performance, and user feedback provided by questionnaires. The literature review, in addition to the local data, provided a range of potential criteria for evaluating CBE. These efforts facilitated the creation of a list of questions that an instructor might use for evaluating CBE. These questions became the instructor's evaluation instrument and are an integral part of this report. The environmental, instructional,

and managerial evaluation model, coupled with Heermann's model of teaching and learning with computers, provides the instructor with a comprehensive model for evaluating CBE.

Construction of a Student Evaluation Instrument for CBE

Based on the completed list of questions just noted, a number of possible items for a questionnaire were developed to be used by students for evaluating CBE. A Likert scale with answers varying from Strongly Disagree to Strongly Agree was used in the instrument. Questions were taken from all three areas of the environmental, instructional, and managerial evaluation model. Also, open-ended questions which address student issues were included at the end of the instrument.

Summary

The methodology employed for the project was exploratory in nature. It focused upon an extensive literature review undertaken by all group members. The review centered around three areas: a) the prevalence of CBE in the professional environment, b) the efficacy of CBE as a learning tool, and c) evaluation of CBE in higher education.

Based on the literature review, it became apparent that defining concepts such as CAI, CMI, CSE, and CBE would be essential to develop coherence for the project, thus allowing for the standardization of the concepts and proper organization of the report.

The core of the study has been predicated on the work of Barry Heermann. His book, Teaching and Learning with Computers (1988), was used to construct the major framework of the study. The study incorporates an in-depth look at Heermann's four major categories: a) learning objectives, b) intellectual skills, c) teaching styles, and d) modes of computer delivery. Heermann correlate these considerations with two dimensions of learning: a) other- and self-directed learning, and b) theoretical versus applied learning.

Lastly, the second framework for the study, the components of CBE, was outlined. These components, instructional, managerial and environmental, serve as domains or areas of concern that need to be considered under the umbrella heading of computer-based education or CBE. This final framework provided the organizational framework around which the criteria for evaluation were organized.

LITERATURE REVIEW

The literature review is divided into three sections: first, computer-based education in the professional environment was explored; this section was followed by a discussion of the efficacy of computer-based education as a learning tool; and finally, the issues and considerations for a CBE evaluation system was outlined. The relevant systems and issues found in the literature review are presented in the following sections.

Computer-Based Education in the Professional Environment

Computer-based education programs are being utilized in many different ways by professionals. Programs exist which assist not only in the instruction of individuals but in the management of that instruction. As discussed previously, CBE consists of computer-assisted instruction (CAI), computer-managed instruction (CMI), and the computer support environment (CSE). CAI and CMI will be discussed in this section, whereas CSE will be discussed in following sections. According to Samojiden and Rauch (1982), CAI is the actual training, involving a direct interaction between the teacher and the learner. CMI, however, is the formulation and management of systems used to "keep records, make assignments, administer tests, or compute grades and progress" (Wehrenberg, 1985, p. 95).

Before discussing the specific methods and applications of computer-based education (sometimes referred to as computer-based training--CBT), it is important to discuss the history of teaching with computers and identify some major CBE systems.

Major Milestones in Educational Computing

In 1954, B. F. Skinner developed a teaching machine used to tutor students. Collagon notes Skinner's teaching program was based on his theory of operant conditioning because responses were conditioned and reinforced by hints, prompts and suggestions (cited in Flynn & Kuczeruk, 1984). This
teaching program is the first recorded example of a tutorial.

Later in the 1950s, the computer industry explored using computers to train their own employees. Suppes and Macken (1978) stated, "it was found that the ability of the computer to provide self-paced, individualized instruction with immediate feedback served a primary educational need that was not being met in the traditional classroom" (cited in Hofstetter, 1981, p. 5).

In the 1960s, with the development of high-level authoring languages, the field of instructional computing became accessible to educational institutions. According to Coburn, Kelman, Roberts, Snyder, Watt & Weiner (1985), authoring languages consist of formatted frameworks that allow a user with little computer knowledge to develop application programs. TUTOR, an authoring language, was developed by the University of Illinois for their newly developed PLATO (Programmed Logic for Automatic Teaching Operations) system. PLATO is a large-scale dedicated (i.e., set aside for a specific purpose) system involving time-sharing with remote terminals. It is marketed by Control Data Corporation and provides a full range of CAI and CMI. Some of the settings for usage include "sales and management training, technical and industrial training, military training, medical education, remedial education in basic skills and hundreds of college and university courses" (Kearsley, 1983, p. 70).

Soon after, IBM introduced COURSEWRITER, an instructional software program used by Stanford University to test the feasibility of using computers to teach elementary level mathematics and reading. This piggyback system (i.e., a software package which runs on already existing computer systems) was called an Interactive Instructional System (Hofstetter, 1981).

In the early 1970s, Brigham Young University, together with the Mitre Corporation, developed the TICCIT (Time-shared Interactive Computer Controlled Instructional Television) system. This dedicated system used Data General minicomputers with Sony television monitors. From TICCIT came a new instructional technique called Learner-controlled Instruction. This system was intended to be self-directed and individually paced (Kearsley, 1983).

The early 1980s saw the introduction of standalone (i.e., microcomputer) systems. With the development of these standalone systems came a great reduction in the cost of computer systems. This reduction of cost, along with the advancement of software technology, has allowed for the realization of much of the potential in the world of computerized instruction. At present there is a full array of linear style teaching programs and non-linear and iterative stacking devices such as hypertext and expert systems. Both linear and non-linear devices show much promise toward the exploitation of technology in instructional computing.

Computer Applications

There are numerous terminologies used to define CBE. To facilitate organization of this report, the educational use of computers has been divided into five categories: a) instruction, b) testing, c) teaching tools, d) problem solving systems and e) management. Most authors place instruction, testing, teaching tools and problem-solving systems under the heading of CAI. These systems are separated in order to illustrate the differences in their function. It should be noted that each of these four systems uses the computer to teach. On the other hand, management uses of computers (also termed computer-managed instruction or CMI) can be more than record keeping and monitoring CAI activity; CMI is available to administrators and teachers to improve effectiveness and efficiency within the entire educational system.

Instruction

According to Hofstetter (1981), "instructional computing refers to the interactive use of the computer as a medium for delivering instruction" (p. 4). Three main types of instructional applications are tutorials, drill and practice, and instructional games.

Tutorials. Alessi and Trollip (1985) state that tutorial lessons are computer programs which teach by carrying on a dialogue with the student. They present information, ask the student questions, and make decisions based on the student's comprehension about whether to move on to new information or to engage in review and remediation (p. 52). In other words, they teach a specific skill or concept and then test for comprehension.

There is a wealth of tutorial programs for patient education in the medical field. Beck, Ellis, Scott, Raines & Hakanson (cited in Norris, Skilbeck, Hayward & Torpy, 1985), describe a patient education system with lessons on general drug knowledge. It is a drug quiz with nineteen multiple choice and six true or false questions. If the user selects an incorrect answer, he/she is told why it was the wrong choice. Programs such as these include education in areas of prenatal care, labor and delivery, nutrition, smoking, cancer, diabetes, and many others. These tutorials are utilized in doctors' offices, hospital waiting rooms or made available to patients for home computer use.

With the rapid progress of accumulated knowledge and the advancement of technology in the medical field, continuing medical education is a constant concern that can be very time-consuming. Tutorials are used to instruct medical students and assist them in their continuing medical education. Piemme (1988) points out that computers do something physicians/students cannot. They can store huge amounts of information that may be made available when needed. This fact may require that the first thing a medical student must learn will be the ability to communicate with a computer.

Many CBE programs used to teach medical students can also be used by physicians in the field. An example of this is RECONSIDER (McClung, Guerriere, & McClung, 1984), which aids physicians in considering all possible diagnoses based on the patient's symptoms. An advantage to this program is that it lists a number of uncommon diseases. Other programs can evaluate and determine the interactions of drugs that may be given to the same individual.

According to Heermann (1988), when deciding which type of training program will best apply for a specific setting, one needs to ask what the learning objectives are for the student and what type of intellectual skills need to be stimulated. According to Heermann's framework, tutorials are the computer delivery mode of choice when the desired intellectual skill is informational and the learning objective is "knowing that". He refers to this type of learning as other-directed, theoretical learning.

Drill and Practice. Drill and practice instruction provides practice in a particular skill once that skill has been introduced. In the drill and practice format, "a selection of questions or problems is presented repeatedly until the student answers or solves them all at some predetermined level of proficiency" (Alessi & Trollip, 1985, p. 52).

In 1981, the University of Illinois replaced two-thirds of the lectures given in freshman chemistry with drill and practice instruction (Hofstetter, 1981). Drill and practice has been used to provide basic skills in mathematics and reading in primary and secondary education. Its primary use is to supplement traditional classroom instruction (Office of Technology Assessment [OTA], 1988).

In a drill and practice program, the user is encouraged to improve the skills previously learned. For example, if drill and practice is utilized to teach mathematical concepts, a certain degree of familiarity is required for the student to interact successfully with the lessons. Coburn et al. (1985) write that drill and practice provides instant feedback, encourages the mastery of skills, and removes the tedium associated with working on skills already mastered.

According to the Heermann (1988) framework, drill and practice programs are best used when the learning objective is "knowing that" and the intellectual skill desired is informational. Drill and practice provides for other-directed, theoretical learning.

Instructional Games. Instructional games have proven to be a powerful method of instruction. Alessi & Trollip (1985) state that games are very much like simulations in that:

> the purpose of both simulations and games is to provide an environment that facilitates learning or the acquisition of skills. Games, however, may or may not simulate reality, but they are nearly always characterized by providing the student with entertaining challenges. (p. 195)

Usually games are used in the instructional setting because of their potential for student motivation and their tendency to focus on the goal of the game. Nesbit (1971) and Maidment & Bronstein (1973) state that games can focus on many areas, including:

1) Facts and principles,
2) Processes, such as the chemical process of titration or real estate acquisition,
3) The structure and dynamics of systems,
4) Skills, such as problem solving, decision making, or the formulation of strategies,
5) Social skills, such as communication,
6) Attitudes
7) A variety of incidental skills such as the nature of competition, how people cooperate, the dynamics of social systems, the role of chance, and the fact that penalties often have to be paid for just or unjust reasons (cited in Alessi & Trollip, 1985, p. 216).

According to the Heermann (1988) framework, instructional games would stimulate other-directed, applied learning, with the learning objective of "knowing how". Instructional games typically use integrational and problem solving intellectual skills.

Testing

Computer testing consists of formulating, administering, scoring, and/or analyzing an assessment tool. Kearsley (1983) discusses five possible functions of computer testing: a) scoring and analysis, b) creation of tests, c) item generation, d) interactive testing, and e) adaptive testing.

Schwartz (1984) notes that computers are often used in the area of psychological testing, specifically in the administering of the Minnesota Multiphasic Personality Inventory (MMPI), a personality test.

The University of Illinois utilized their PLATO system to administer a Federal Aviation Administration examination on an experimental basis to approximately 150 people seeking formal certification over a period of 18 months (Alessi & Trollip, 1985).

Western Michigan University currently uses computer-assisted testing to aid graduate social work students in learning social work research methods. Approximately 100 students each semester have access to the quiz items in the computer laboratory.

According to the Heermann (1988) framework, computer testing has the potential to stimulate both other-directed, applied learning and other-directed, theoretical learning. The framework would address intellectual skills that are informational in nature and where the desired learning objective is "knowing that".

Teaching Tools

Teaching tools refer to hardware or software that help a user do a particular task or tasks. Computer-assisted technology has incorporated teaching tools such as the word processor, electronic spreadsheet, computer-assisted design, and voice synthesizer, each of which can assist or enhance the educational process. "These programs help students develop classificatory and analytical skills and achieve the learning objective of 'knowing what and why.' They are often used by instructors with the preferred instructional style of Broker" (Heermann, 1988, p. 215).

The word processor has gained wide-spread application in both education and business. It can be used to teach secretarial skills, general business skills, and composition skills. "Teachers find that students are more willing to fix spelling and grammatical errors, even revise entire compositions, when the amount of repetitive typing is drastically reduced" (Alessi and Trollip, 1985, p. 53).

Word processors assist individuals who cannot hold a pencil to write. Jamie, a young boy with motor problems who took hours to write his homework, can now complete it in minutes (OTA, 1988).

Another widely used teaching tool is the electronic spreadsheet. A spreadsheet is essentially a computerized ledger book, with rows and columns, used to keep track of such matters as sales, purchases, and taxes. "Business teachers use them to teach accounting and other courses. Math instructors use them as a tool for doing calculations, and science teachers use them to collect laboratory data and do laboratory calculations" (Alessi & Trollip, 1985, p. 54).

Computer-assisted design (CAD) is another teaching tool. The computer programs used to support design efforts include homework problems, system simulations, design problems, and design analysis. At West Point Military Academy, CAD is used in scenarios simulating actual conditions where a military application of engineering principles is desired (Grubbs, Meszkevitz, & Ennis, 1986).

A company such as Prab Command, Inc., in the field of robotics, utilizes voice synthesis to allow a handicapped user to give verbal instructions to the computer. These instructions can lend assistance in daily living in such ways as dialing telephone numbers or programming a mechanical arm to retrieve objects. In special education classrooms, voice synthesizers allow students who cannot speak to communicate orally (OTA, 1988).

According to the Heermann (1988) framework, when the computer delivery mode is that of a tool, the learning stimulated is self-directed, applied learning. The learner applies analytical skills to the learning objectives of "knowing what and knowing why."

Problem-Solving Systems

The most valuable aspect of education is its ability to do more than teach facts. Heermann (1988) notes that the student must move beyond "knowing that" to "knowing how". In order to develop these abilities, students must develop problem-solving and integrative skills.

CBE programs that are branches of artificial intelligence include expert systems, hypertext, and simulations. Clinical and biomedical applications of artificial intelligence (AI) as described by Freiherr (1984), "attempt to capture the effectiveness of human expertise without necessarily trying to model what goes on in the human mind" (p. 459). Freiherr notes that AI models, including problem-solving, language-processing, and inferential reasoning, are being assembled at Carnegie-Mellon University under the direction of Dr. John Anderson. Known as Acquisition of Cognitive Procedures and nicknamed ACT, the program is designed to model the development and performance of decision-making. The ACT research project contains a logic scheme that may transfer to applications in specific areas in or outside of medicine. "We hope that future versions of ACT will resemble very closely the process by which people learn to make decisions," Dr. Anderson says. "We could then apply this model of skill acquisition to such medical domains as diagnosis and scientific inference" (Freiherr, 1984, p. 459).

Expert Systems. The purpose of an expert system is the transfer of knowledge to the user. An expert system can be defined as "a program that allows the user to query a data base representing 'expert' knowledge of the rules and principles that apply to a certain subject or discipline" (Heermann, 1988, p. 204). Shafer (1988) calls an expert system "a computer program specifically designed to represent human expertise in a particular domain" (p. 26). These programs provide many opportunities for CBE to be utilized to encourage students to take an active role in the learning process.

The CBT Analyst, which was copyrighted in 1987 by Park Row Software, is an expert system that allows the user to consider the use of CBT in a particular setting. The system uses its knowledge base to determine what courses may be appropriate for CBT and the particular CBT system to utilize. CBT Analyst estimates the costs--which include monetary costs and time--and assesses the costs/benefits of CBT. CBT Analyst predicts the success of CBT and produces a summary report regarding the queried areas.

Expert systems provide other-directed, theoretical learning according to the Heermann (1988) framework. The system directs the user through specified information until the material has been mastered. "Knowing that" is the learning objective of the expert system.

Hypertext. Yankelovich, Meyrowitz & van Dam (1985) state that

> the term hypertext was coined by Ted Nelson to denote nonsequential writing and reading. Both an author's tool and a reader's medium, a hypertext document system allows authors or groups of authors to link information together, create paths through a corpus of material, annotate existing texts, and create notes that point readers to either bibliographic data or to the body of referenced text. (cited in Por, 1987, p. 14)

An extension of hypertext is hypermedia, which Yankelovich et al. (1985) describe as having "the functionality of hypertext with additional components such as two- and three-dimensional structured graphics, paint graphics, spreadsheets, video, sound, and animation. With hypermedia, an author can create links to complex diagrams, text, photographs, videodiscs, audio recording and the like" (cited in Por, 1987, p. 14).

In an article in IEEE Computer, Yankelovich, Haan, Meyrowitz & Drucker (1988) of Brown University explain the potential of Intermedia, which is a hypermedia system. With Intermedia, the author has the ability to link information and present it in various ways. The student, or user, has the option of choosing the various ways to explore the material. "Regardless of form, irrespective of subject matter and independent of delivery vehicle, it is the interrelatedness of the knowledge and the techniques by which its parts are connected that is significant..." (Shafer, 1988, p. 26).

Referring again to Heermann's (1988) framework, hypertext can be seen as either self-directed applied learning or self-directed theoretical learning. In either case, the learner directs her/his own learning through the linkages available in the hypertext material.

Simulation. Coburn et al. (1985) define a simulation model as "imitating a real or imaginary system based on the modeler's theory of the operation of that system" (p. 36). The power of a simulation model is derived not from the mastery of content, but from the advanced thinking and problem-solving skills involved. Instructional simulations cause the learner to analyze, synthesize, and apply basic knowledge to complex problem-solving situations. The OTA Report (1988) states that simulations "train students to break down problems into their component parts and set strategies for their solution" (p. 12).

Most of the programs utilized by medical schools are simulations. One such program simulates problems when initiating insulin treatment for diabetic patients. The student decides on the appropriate diet and insulin prescription. The results of his/her decisions can be monitored by requesting urinalysis and blood-sugar determinations. If the student makes a mistake, only his/her ego is damaged. Other uses of simulation programs include the simulation of case problems to improve skills, provide feedback on performance , and simulate emergency situations (Nardone, Schriner, Guyer, & Kositch, 1987).

Flynn (1985) discusses three reasons for applying simulations in teaching policy in human service settings.

> First, policy processes are often very slow and the timing of the process cannot generally be compacted for learning purposes....
> Second, it is very difficult to directly connect the theoretical explanations of the policy process with what occurs in the reality of human interaction over time and space....Third, and perhaps most important, there are certain ethical issues associated with setting up situations or 'exercises' in which policy is somehow purposefully manipulated for learning purposes. (pp. 33-34).

Flynn (1987) has applied simulations to his social policy seminars. He states that he has "created hypothetical situations such as simulating the development and passage of a bill through the state legislature, another in resolving conflict in interagency processes, and a scenario in consensus-building in interagency and consumer relationships around a program budget" (p. 18).

Simulations are also used to conduct experiments in science, math, and social studies classrooms to provide students a world "in which they can experiment and quickly see results" (OTA, 1988, p. 12). These experiments are such that they may not be safe or feasible in actual classroom work.

Simulations, then, are a further application of other-directed, applied learning in the Heermann (1988) framework. The objective of the instruction is "knowing how", utilizing problem-solving and integrational skills.

Management

Computers are used to keep records, make assignments, administer tests, or compute grades and progress. This process is known as computer-managed instruction (CMI) (Wehrenberg, 1985). Kearsley (1983) says that "CMI is usually used to improve the level of control and efficiency within a training system" (p. 25).

Davis (1978) and Van Matre (1978) state that the U.S. Navy uses CMI to manage the daily instruction of about 10,000 students and to generate detailed reports of student progress (cited in Kearsley, 1983). Branscomb (cited in Kearsley, 1983) writes that International Business Machines Corporation (IBM) uses CMI to ensure that employees have mastered the instructional materials via on-line testing.

In the school system, uses of CMI by teachers and administrators have been noted by Coburn et al. (1985) to

> measure and keep track of student performance and activity in a variety of areas. For example, records must be kept on student mastery of objectives, individual educational plans (IEP's) must be generated and monitored for special needs students, reports must be generated to receive funding, and evidence of achievement has to be given to parents at conferences (p. 59).

Software Clearinghouses

The reader may wish to become familiar with resources emerging or already in place to support instructional computer applications in higher education. Among these are the National Collegiate Software Clearinghouse of Duke University Press (formerly at North Carolina State University), the WISC-WARE software center at the Academic Computer Center at the University of Wisconsin--Madison, ISAAC (Information System for Advanced Academic Computing) at the University of Washington, the Digital Equipment Company's CLEARINGHOUSE at Iowa State University, and the disk distribution service provided by the CUSS Network (i.e., Computer Users in Social Services) located at the University of Texas at Arlington. These organizations provide access to existing software for higher education and encourage the development and submission of new additions to their catalogues or listings.

Review of the literature has shown that the development of CBE began in the 1950s. With the advancement of computer technology and the development of authoring languages, instructional computing has realized much of its potential.

Currently many educational uses of computers exist. Educational uses of computers are found in five categories: a) instruction, b) testing, c) teaching tools, d) problem solving systems, and e) management. The first four categories are considered to be CAI, and use the computer to teach. Management, on the other hand, is the manipulation of the data derived from, or used for, instruction as well as the use of computers to increase the effectiveness and efficiency of the educational system.

Computer applications for each category have been illustrated. These applications consist of tutorials, drill and practice, instructional games, testing, teaching tools, expert systems, hypertext, simulations, and management. It has been shown that each system has extensive use in fields such as education, medicine, business, and the military.

When deciding which type of program will best apply for a specific setting, the project group found it useful to use the framework developed by Heermann (1988). According to Heermann, before deciding on a computer delivery mode, one needs to ask what the learning objectives are and what type of intellectual skill needs to be stimulated.

The Efficacy of Computer-Based Education as a Learning Device

The purpose of this section is to consider the outcomes of computer-based education. A great deal of research has been developed on the efficacy of CBE in the last 20-plus years. Some researchers have conducted their own studies evaluating CBE for effectiveness. Other researchers have synthesized data collected from many independent studies; this type of research is called meta-analysis. Kulik & Kulik (1988) identified 254 such studies in their latest meta-analysis. The same authors did a meta-analysis of 101 studies specific to college level use of CBE which was published in 1986.

Kulik & Kulik (1988) report that the methodology of meta-analysis requires the researcher "(a) to locate studies of an issue through objective and replicable searches; (b) to code the studies for salient features; (c) to code study outcomes on a common scale; and (d) to use statistical methods to relate study features to outcomes" (p. 6). Results of these reviews are reported in standard deviation units, and investigators study relationships between these outcomes and study features, thus integrating findings from many individual studies.

There were difficulties in some of the individual research studies, however, which caused meta-analysts to carefully screen the studies that were included. Faas (1984) lists the following factors that undermine the worth of some of the individual studies:

1) Sloppy research designs.
2) Vested interests on the part of the researchers.
3) Combination of data from mainframe and microcomputer based instruction.
4) Mixing of data from programs that use drill and practice with data from other types of CAI.
5) Mixing data from studies in which CAI supplemented conventional instruction with data from studies where CAI replaced conventional instruction.
6) Use of different software from study to study.
7) Failure to control the age and grade levels of the students included in some studies.
8) Failure of researchers to report complete data. (p. 142)

It was problems such as these that caused Kulik, Bangert and Williams (1983) to eliminate 250 of 300 research studies when they did their first meta-analysis of CAI effectiveness. However, because of this rigorous analysis of research methodology and procedures, the data which remains from the meta-analyses can be considered to be very high quality. These meta-analyses will be relied upon heavily in this section of the literature review.

The 1988 meta-analysis by Kulik & Kulik specifically relates to university education, the topic of this research project. They report that the studies included in this analysis met four criteria. First, the studies took place with real teaching, not analogues of teaching, in college classrooms. Second, both computer and conventionally taught groups had to be measured quantitatively in the same way. Every experiment had to be quantified and controlled. Third, the studies had to be free from the kinds of errors reported above. Finally, studies had to be available from Educational Resources Information Center, the National Technical Information Service, University Microfilms International, or by interlibrary loan. These studies categorize measurements of outcome into four basic areas:

1) Learning outcomes,
2) Attitudes toward instructional quality and course content,
3) Attitudes toward computers, and
4) Instructional time.

This report on CAI efficacy has been organized around these four themes.

Learning Outcomes

The most frequently reported evaluation outcome is some measure of student learning: achievement scores, retention, or performance.

Although computer assisted instruction may initially have been thought of as a novelty that would make learning more fun (Oates, 1982), overall results consistently show that students using CAI have better learning outcomes, measured as examination averages, either in achievement or performance during the course or retention in follow-up studies.

Buckley and Johnson found "dramatic cognitive growth" (cited in Faas, 1984) in their use of CAI with adult learners:

1) CAI has a positive impact on cognitive growth when used properly. The affective changes associated with CAI are even more significant.
2) Students who use CAI are more likely to perceive themselves as capable learners.
3) Students who use CAI become increasingly self-directed in their learning style. They become more responsible for learning and less dependent on teachers.

4) Students who use CAI are able to identify for themselves specific skill areas in which they have improved, as well as areas in which they need to improve.
5) Students who use CAI can watch their own scores and are able to see general progress.
6) The students' affective growth results in more rewarding learning experiences for students and helps account for the improved cognitive growth and more regular attendance among CAI users.
7) CAI has proven to be an invaluable component of an adult basic education program. (pp. 144–145)

Kulik and Kulik (1986) analyzed 101 studies that were conducted on the effectiveness of CBE in college classrooms. Using computers for drill and practice, tutorials, problem-solving, data-processing, simulations, and evaluation was equally effective, all contributing positively, though moderately, to student learning. These conclusions were drawn from the results of final examination scores. An updated analysis of 254 studies recently completed by Kulik and Kulik (1988) built upon the prior studies. In 248 of those studies that reported final examination scores, 81% showed that students in CBE classes had higher examination averages than students in conventionally taught classes. In 94 of these studies, the difference favoring the CBE students over the conventionally taught student was statistically significant. Twenty studies measured retention of learned material after 2 to 10 weeks; again, there was a positive, although moderate, effect.

In a study in which college students learned study skills through CAI, Hartig (1985) also found that, with increased experience on the computers, students performed better on academic tests. Further, students had a better understanding of course materials, were able to reduce study time, and were convinced of the value of the CAI lessons.

It has long been an accepted fact that people learn best in a diversity of ways. It is equally true that not all students approach CBE with equal strength, interests, or even the desire to include computers in their learning process. Some learners may value CAI in which the software processes are highly transparent, allowing the student to just do the work. Other learners, however, value understanding the capabilities and limitations of the computer.

Patricia Galagan, editor of the Training and Development Journal, presents an interesting discussion of the ways in which people learn with computers (1987). She cites interviews with noted specialists involved in integrating computer technology and learning styles who recognize the differences between left-brain/right-brain and deductive/inductive learners. They conclude that more work needs to be done in understanding how people learn best with computers.

Attitudes Toward Instructional Quality and Course Content

Students involved in CAI classes reported more positive ratings than students receiving conventional instruction (Faas, 1984). Kulik & Kulik (1988) report that 34 studies examined the effects of CAI on student attitudes toward the subject matter that they were being taught. Twenty of the 34 studies reported that student attitudes in CAI classes were more favorable than in conventional classes.

Attitudes toward the quality of instruction of CAI over conventional classroom instruction were high (Faas, 1984). Oliver & Huxley (1986) state that 80% of social work students using computerized exercises found them worthwhile, enjoyable, rewarding and stimulating. Kulik & Kulik (1988) reported that in 16 of 22 studies, students using CAI perceived that the quality of instruction was higher than students taught in the conventional classes.

Environmental factors also affect attitudes towards CAI. In a study done with librarians receiving CAI, Albretton & Sievert (1988) discovered that age, job classification, previous experience with computers, or number of years of working at the library did not differentiate librarians' attitudes towards CAI. The most significant differentiation between high and low participators in the instruction was whether or not the instruction was convenient to their schedule and location.

Attitudes Towards Computers

CAI appears to have an important positive effect on students' attitudes toward computers and to a lesser degree has a positive effect on students' school attitudes (Kulik & Kulik, 1988). Hartig (1985) found that students' attitudes towards computers improved after their experience with CAI for study skills courses. Kulik & Kulik (1988) reported that in 15 of 19 studies focusing on students' attitudes toward computers, positive changes occurred after contact with the computers. Students are most favorable when the CAI supplies them with factual knowledge, and the positive attitudes occur when the computer is an integral part of the coursework.

Instructional Time

Research supports CAI as being more time efficient than conventional classroom instruction. Orlansky (1983) reported that military students were able to complete their courses more quickly in 44 of 48 cases when learning by CAI compared with conventional instruction. Even though their achievement scores were about the same, the median saving time was about 30%. In discussing training programs, Dossett & Konczak (1985) show that individual CAI training time is 37% faster than conventional instruction and that CAI training done by peers took even 20% less time than individual CAI instruction. In one study with PLATO, some students spent more time, but they reported this extra time was due to their enjoyment in working with the materials on the computer. However, 55% of the students reported that they took less time because the learning was easier (Hartig, 1985).

Kulik & Kulik's meta-analysis (1988) involving instructional time uncovered 32 post-secondary level studies. CAI students required one-third less time than students taught by conventional methods. Only three studies reported more time for CAI than for traditional instruction.

Buckley and Johnson (cited in Faas, 1984) have reported major learning gains through the use of CAI. They have identified several major factors which contribute to the effectiveness of CAI:

1) CAI is individualized; that is, each student moves entirely at his/her own pace, totally unaffected by the performance of any other student.

2) CAI provides up-to-the minute diagnosis of the student's areas of strength and weakness, thus helping teachers perform their tasks more thoroughly and efficiently.

3) CAI can be structured to allow the student a limited amount of time to respond to the questions presented. Most students find this helps them improve both their rate of comprehension and ability to concentrate.

4) CAI, unlike most available print-media, provides the student with feedback on his/her responses.

5) CAI utilizes a reporting system which provides the student with a clear picture of his/her progress.

6) CAI became a much more effective learning tool as adult students using it ceased to perceive it as being experimental and game like. (p. 144)

Kulik and Kulik (1988) note:

> No individual outcome study, however, can show whether CBI [computer-based instruction] is generally effective. To reach general conclusions, reviewers must take into account the results from numerous studies carried out on different places, at different times, and under different conditions. It would be as pointless to judge all CBI programs by a single outcome study as it would be to judge all textbooks, lectures, or films by a single comparison. (pp. 2-3).

With the finding that the effectiveness of CAI can exceed conventional instruction, the literature suggests that there is justification for further program implementation. CAI can be a powerful adjunct to the activities of both teachers and students. It can free teachers of the routine repetitive tasks associated with instruction so that classroom discussion can enhance individual students' instructional and personal learning needs. Furthermore, CAI can be implemented to teach virtually any subject.

Effectiveness of CAI in college courses is dependent upon such factors as voluntary participation by the students and the CAI lessons being a part of a larger, overall educational program and implemented in conjunction with larger educational objectives. The software must take advantage of the computer's interactive capabilities and it must be of pedagogical quality (Faas, 1984; Hartig, 1985).

Although CBE research has observed great consistency in outcome, there are limitations in the research. Even newly published articles often report research designed and carried out years earlier due to the lag time between completion of the project, writing results and publication. Consequently, the reports in the literature often are not of the most recent findings.

It is worthwhile to note that Kulik & Kulik (1988) found measurable outcomes of CAI to be smaller in studies of longer duration, for example, studies that last a semester as opposed to ones lasting a week. What has come to be called the Hawthorne effect may partly explain these results. "A novelty effect occurs when learners are stimulated to greater efforts simply because of the novelty of the treatment. As the treatment grows familiar, it loses its potency" (Kulik & Kulik, 1988, p. 19). It may be that the rapid initial increases in learning are mitigated over longer periods of time. Short-term experiments, however, have used different instruments of measurement than longer studies and are more easily controlled. The difference in methodology may account for the difference in outcome.

Measurable outcomes are also smaller on studies conducted at the college level than in elementary education. Students at the elementary level are being initially exposed to computers as learning tools. Thus, the Hawthorne effect may explain why the effectiveness of using computers diminishes incrementally from elementary school through secondary, with the smallest outcomes at the college level. Further, elementary environments are more easily controlled for research purposes than are university classrooms, in which computers are often in places other than the classroom. University students may have more difficulty accessing the on-campus computers due to commuting and other access problems. Kulik & Kulik (1988) also suggest that the more complex skills which are approached in higher education may not have been effectively captured in CBE programs. Bracey (1987) notes "courseware for the college level

must be much more sophisticated to be effective.... It's much easier to write a program conveying basic math operations than a program that simulates conservation of momentum" (p. 23).

In spite of these problems, CBE results, even from the meta-analyses which cover extensive quantities of research and which employ rigid standards for inclusion, remain positive.

Implications for Future Studies of CBE Effectiveness

It is essential that the most recent research available be published quickly in order to make the most effective use of computers. The hardware and software is changing so rapidly that earlier conclusions drawn and applications made need to be updated. Designers of CBE no longer see the computer solely as a capable drill mechanism but as a device that can be used in many ways, in a variety of subjects, for a multitude of goals. Continued studies need to be made regarding the effectiveness of these new uses of the microcomputer and CBE. Kulik & Kulik (1987) reported that there has been a trend toward greater effectiveness of CBE over time, and we now need to know if this trend continues.

Research studies need to continue in which there are stringent standards for quantification and replication and in which control groups can be compared with experimental groups. However, it is not always possible to meet those standards with the expanded use of CBE evaluation. Evaluation needs to be undertaken even if control groups are lacking or if two or more classes utilizing CAI are taught with different styles. The purpose of CAI evaluation as a support for improving instruction must be kept in mind.

Evaluation Systems for Computer-based Education

The need for an evaluation system for CBE becomes clear from a review of the literature. Reasons for developing an evaluation system, as well as specific suggestions for the content of any good evaluation system, were found at every turn. The reasons for evaluating CBE are many: proving that it is compatible with education and the education system (McEwing & Roth, 1985), justifying the cost/benefit reward in terms of both student and teacher (OTA, 1988), ensuring that the CBE system teaches the student and uses appropriate instructional techniques, and determining if the program itself is clean and bug-free (Zemke, 1984).

What is Evaluation?

Before considering the types of and guidelines for evaluation, it is useful to define evaluation and determine its purpose. Worthen and Sanders (cited in Truett & Gillespie, 1984) report that evaluation is the "determination of the worth of a thing" (p. 23). Truett and Gillespie go on to say that this definition implies that a judgment must be made about the phenomenon being evaluated, such as a behavioral objective, a curriculum unit, or an educational media project (Truett & Gillespie, 1984). Another definition of evaluation is offered by McEwing and Roth (1985), who define evaluation as a "tool to gather information regarding the effectiveness and efficiency of CBE" (p. 33). Borich and Jemelka (1981) define the purpose of educational evaluation as a way to "provide decision makers with information about the effectiveness of an educational program, product or procedures" (p. 161). They go on to say that this type of evaluation is a process in which data is obtained, analyzed, and synthesized into relevant information for decision-making. Borich and Jemelka point out that, while most evaluation activities fit within their definition, the specific approach used and procedures employed vary as a function of who is doing the evaluation, the context within which it is to occur, and the desires and needs of the individual or agency contracting the evaluation.

Conceptual Models for Evaluation

Borich and Jemelka (1981) contend that, while there is a fundamental agreement on the role of evaluation in education, the conceptual models vary considerably and generate much debate. Two possible ways to approach the choice of an evaluation model are: a) to select a general model which most closely fits the evaluation needs, and make it more specific, or b) to adapt a model developed for a specific setting and generalize it to the evaluation need at hand (Borich & Jemelka, 1981). As there is considerable debate among the evaluation experts over which method is best, that decision is properly left up to the evaluator. In this section, several popular types of evaluation models are enumerated.

Discrepancy Model

As reported by Borich and Jemelka (1981), the Discrepancy model was first developed by Provus. In the Discrepancy model, evaluation is divided into five stages. Stage 1 documents program description; Stage 2 uses field observations to determine if the program is being implemented as intended; Stage 3 determines whether the program components are meeting the intermediate educational objectives; Stage 4 determines whether the program components are leading students to the end goal; and Stage 5 (if applicable) compares an experimental program to a realistic alternative.

Stake's Model

A second evaluation model is Stake's concept of evaluation. Stake divides educational programs into three concepts: antecedents (conditions existing prior to training which may affect training outcomes), transactions (for example, student encounters with the teacher), and outcomes (measures of impact of instruction upon the student, teacher, administrators, etc.). These three concepts are then examined for the contingencies that may exist between the three, the congruence between the intended and the observed parts of the concepts, and the empirical contingencies between observed antecedents, transactions, and outcomes (Borich & Jemelka, 1981).

The CIPP Model

A third model is the CIPP model developed by the Phi Delta Kappa Commission on Evaluation (Stufflebeam, Foley, Gephart, Guba, Hammond, Merriman & Provus, 1971). In this model, the evaluation is divided into four categories: context evaluation, input evaluation, process evaluation, and product evaluation.

Formative/Summative Model

A fourth model of evaluation commonly found in the literature is the Formative/Summative approach first coined by Michael Scriven (Truett & Gillespie, 1984). This type of evaluation has also been referred to as a Process/Product evaluation model (Kozma, Bangert-Drowns, & Johnston, 1987; McEwing & Roth, 1985). Formative evaluation refers to evaluating a product while it is being developed, wherein the feedback is used to monitor progress and/or to make immediate changes. Summative evaluation is used to evaluate the total, completed product. It can occur either before or after the product is used (Kearsley, 1983: Truett & Gillespie, 1984).

Effort, Efficiency, & Effectiveness Model

A fifth model found is the Effort, Efficiency, Effectiveness evaluation model described by Austin, Cox, Gottlieb, Hawkins, Kruzich & Rauch (1982). Effort refers to measuring time and energy invested in delivering the services (usually obtained through some sort of monitoring activity); effectiveness refers to the question: "did it work?"; and efficiency measures the relationship between effort and outcome.

Goal Model

A sixth model of evaluation can be described as goal-directed/goal-free. In essence, goal-directed evaluation looks at the question of whether the program reached its explicitly stated goals, while the goal-free approach evaluates the progran. by looking for unexpected outcomes (McEwing & Roth, 1985).

Guidelines for Evaluating CBE

The following discussion utilizes the framework described in the methodology section of this report as a means for organizing and summarizing the project's review of the literature on guidelines for evaluation. What follows is a brief discussion of the most commonly mentioned CBE evaluation components as revealed by the literature search.

Instructional Component

The instructional component of CBE is defined here as anything having to do with the substance of instructional material and how that material is conveyed. Several areas are mentioned in the literature search which would fall under this rubric:

1. Content is one such area. This includes proper grammar and spelling; accurate, up-to-date, and appropriate material; and the breadth of material, which should be neither too large in scope nor too focused (Braun & Slobodzian, 1982; Caffarella, 1987; Northwest Regional Educational Laboratory [NWREL], 1982; OTA, 1988).

2. Proper attention to value considerations is another area. This includes appropriate characterization and/or attention given to issues of race, gender, or ethnicity (NWREL, 1982; OTA, 1988) or whether the teaching of values themselves appropriately falls within the domain of CBE (Braun & Slobodzian, 1982).

3. Another consideration is whether the CBE being used is consistent with the overall course goals and objectives (Caffarella, 1987; Coburn, Kelman, Roberts, Snyder, Watt & Weiner, 1982; NWREL, 1982; OTA, 1988).

4. Whether the program reflects the teacher's creativity and stimulates the students' creativity should also be examined (NWREL, 1982; OTA, 1988).

5. Another concern is whether the program taught the student anything--that is, do the students learn what the teacher's instructional objectives set out to teach? (Heermann, 1988; NWREL, 1982; Zemke, 1984).

6. Appropriate use of instructional techniques is also an important issue. For example, did the instructor choose the CAI type (simulation, game, drill & practice, etc.) which best conveys the course material? (Caffarella, 1987; Zemke, 1984).

7. The question of whether the program motivates the student should also be considered (Zemke, 1984).

8. Another consideration is that the program contain clear instructions for use of the material (Coburn et al, 1982).

9. Another objective is that the program fits the educational level and needs of the audience (NWREL, 1982).

10. The question of whether the audio, graphics, and color enhance the learning of the student and are used appropriately to convey course materials should be considered (NWREL, 1982; OTA, 1988).

11. Another issue is student attitudes towards the CBE program. For example, Magidson (1978) mentions items such as: "I enjoyed using PLATO", "I felt comfortable working with PLATO", "I learn better in classes using PLATO than in classes that don't", and "PLATO made helpful comments on my work" in his example of a "Student PLATO Survey" (p. 17).

12. The purpose of the package should be well defined. This includes such issues as explicit and clear objectives which are stated in terms of expected student behavior (NWREL, 1982).

13. Clear and logical presentation of the material is another issue to be evaluated (NWREL, 1982).

14. Another consideration is whether the program is a babysitter for the instructor (Magidson, 1978).

15. Finally, the learner should be able to control the rate and sequence of the presentation of material and the review of the material (NWREL, 1982).

When developing evaluation materials for CBE, the evaluator should develop instruments which reflect all of these criteria for evaluating the instructional component of CBE.

Managerial Component

The managerial component of CBE has to do with managing, storing, and manipulating the data generated by the instructional materials of a computer program.

1. One consideration is whether the program allows for comprehensive data collection (McEwing & Roth, 1985; OTA, 1988).

2. Another managerial component is whether the system allows for feedback from and for the students (Coburn, et al, 1982; NWREL, 1982).

3. The program should allow for proper maintenance of student records (OTA, 1988).

4. The program should be bug-free . . . that it runs without any technical glitches which might confuse the user (Coburn, et al., 1982; Zemke, 1984).

5. Another issue to consider is whether the program keeps track of student time spent on item, task, program, etc. in order that an analysis of appropriate mastery or learning, as well as desirable cost/benefit, may be considered for each student and class (Caffarella, 1982; OTA, 1988).

6. The managerial aspects of the program should be easy enough to use so that they save time for the instructor (OTA, 1988).

7. The program should have utilities which allow the instructor to make modifications easily (OTA, 1988).

Each of these managerial features should be considered in any evaluation of CBE.

Environmental Component

The environmental aspects of a CBE program refer to the many factors that are encountered by students, faculty, and the organization sponsoring CBE that either impede or assist CBE. There are many considerations in this area.

1. Identification of any potential political problems which might affect the implementation of the CBE is one environmental consideration (McEwing & Roth, 1985).

2. Another concern is cost considerations: does the educational institution have sufficient computer software, hardware, and facilities to allow for CBE use by the class and is there enough money in the budget to allow for the development of CBE? (McEwing & Roth, 1985).

3. The equipment should be compatible with the CBE software being used (Zemke, 1984).

4. An additional consideration is whether the computer setting is motivational for the students. That is, do the students feel comfortable using the computers available to them? (Coburn, et al, 1982; NWREL, 1982; OTA, 1988).

5. Administrative, teacher, and student attitudes should be considered. If they are not favorable, steps should be taken to promote computer literacy before implementing CBE (Holmes, 1982).

6. Another criterion is that user time should correspond with available time at the school's computer facilities (Holmes, 1982).

7. An overall evaluation should be carried out by the instructor (Caffarella, 1987; Coburn, et al, 1982; OTA, 1988).

8. The learner should be able to control the computer environment in terms of audio, visual, temperature, or other variables (NWREL, 1982; OTA, 1988).

9. The technical capability to use the program needs to be easily comprehended by the learner (Coburn, et al, 1982; NWREL, 1982; OTA, 1988).

10. The program should be able to handle errors easily which might be introduced by the students (Coburn, et al., 1982). That is, the program should be error-trapped.

11. The program should include user/student support materials which are both comprehensive and effective (NWREL, 1982; OTA, 1988).

12. Perhaps most importantly of all is whether the organization or institution has an adequate planning process in place to support CBE development (Smallen, 1989).

Again, the evaluator should consider each of these matters or criteria when developing an instrument or procedures to evaluate the environmental aspects of a CBE program.

The literature review on the evaluation of CBE supports the need for a comprehensive evaluation system for a computer-based education program. The first step an evaluator takes is to choose an appropriate evaluation model. Some appropriate models are: Discrepancy Model; Stake's Model; CIPP Model; Formative/Summative Model; Effort, Efficiency, & Effectiveness Model; and Goal Model. Each of these models approach evaluation in a different manner, using different criterion with which to evaluate. The evaluator must decide upon a model to best fit the evaluation need(s) of a particular CBE program. Using the essential evaluation components outlined above and any program-specific considerations which should be included, the evaluator can begin the task of constructing an evaluation approach specific to his/her own CBE program.

Summary

The literature was reviewed to determine the essential ingredients for evaluating computer-based education. This review focused on three primary areas. The first section, Computer-Based Education in the Professional Environment, determined to what extent computers are used in education and training for professionals. The specific methods and applications of CBE are preceded by an overview of the history of teaching with computers, and a presentation of some current major CBE systems. The second section, The Efficacy of Computer-Based Education as a Learning Device, outlined what the literature says regarding the efficacy of CBE. The Kulik and Kulik (1986) meta-analysis of college level CBE was utilized to present findings in four categories that consistently produce favorable measurable outcomes. Finally, the third section, Evaluation Systems for Computer-Based Education, discussed some prevalent evaluation models and the components of an evaluation system. This final section presented reasons for conducting evaluation as well as specific suggestions for the content of a comprehensive evaluation system.

FINDINGS AND RECOMMENDATIONS

In the section that follows, this report will first provide a rationale for the selection of what the authors chose to label the "EIM Model for Evaluating Computer-Based Education." That is followed by a listing of questions for the developer or instructor evaluating CBE and a potential list of items for a questionnaire for student users. The section ends with a presentation of other project recommendations.

The EIM Model for Evaluating Computer-Based Education

The literature review supports the conclusion that CBE is not only prevalent in the professions and higher education but is also an effective way of attaining learning objectives. The efficacy of CBE has been demonstrated by increased learning outcomes, positive student attitudes, and efficient use of instruction time. Furthermore, the literature review supports the need for CBE evaluation.

In developing a comprehensive evaluation system, this project team examined a number of considerations that influence decisions in implementing and evaluating computer-based education programs. These considerations include the computer application desired, what is known about the efficacy of a particular approach, and a variety of issues in evaluation.

Heermann's model of teaching and learning with computers demonstrates that alternative teaching styles and computer delivery modes are required for different learning objectives and desired intellectual skills. Therefore, instructors will have individual CBE program needs as well as individual evaluation needs. For instance, creativity may be a course objective when hypermedia is used and therefore evaluated, but not an objective when a tutorial is used.

This project group considered a number of evaluation models. As discussed previously, when choosing an evaluation model one must first examine the evaluation needs of a particular CBE program. The issues and questions generated by the components of environment, instruction, and management themselves suggest a useful model for evaluation. Furthermore, it is logical to order the components of this model to reflect the timing of particular considerations. The project team decided that this newly developed model would be titled the EIM--environment, instruction, and management---model. These three components have been ordered to suggest that environmental issues should be considered prior to instructional issues, which in turn should be considered prior to managerial issues.

To aid the instructor in developing evaluation guidelines using the EIM model, this project team developed two evaluation tools. These evaluation tools consist of: a) a list of evaluation criteria to assist the instructor or program developer and b) a student user questionnaire.

The categories of evaluation criteria are outlined as follows.

I. Environmental

- a. political
- b. costs
- c. hardware/software
- d. motivation
- e. computer literacy
- f. convenience for students

II. Instructional

a. goals/objectives
b. content
c. format
d. values
e. creativity
f. student attitude toward usage
g. achievement and learning outcomes

III. Managerial

a. record keeping
b. author support and utilities
c. evaluation

This outline of categories serves as a list to generate more specific questions, which will be presented in the next section.

Criteria to Be Considered in CBE Evaluation

The evaluation criteria which follow are written as a list of questions directed to the instructor. They are not intended to be used in toto but rather as a cafeteria from which to choose when evaluating CBE. These criteria have been organized into the EIM model. Environmental considerations are those that assist or impede CBE. Instructional considerations include what is taught and how it is taught. Managerial considerations are defined as the manipulation of data and the methods by which data are stored.

I. Environmental Factors

A. Political considerations

1) Is there a planning process in place for the development and support of CBE?
2) Is there a reward system for development of CBE?
3) Is adequate collegial and administrative support given to instructors developing CBE?
4) Are adequate resources (money, time, space, equipment) allocated for development and implementation of CBE?

B. Costs

1) Is the development and implementation of CBE cost effective?
2) Is the cost of software, hardware, and facilities justified?
3) Is cost a prohibitive or a delimiting factor?
4) Is CBE time effective for the instructor?

C. Hardware/Software

1) Are error-trapping methods in place to prevent the student from error-related frustrations (wasting time, ruining the program, etc.)?
2) Is the equipment compatible with CBE software?

3) Are adequate arrangements and support provided for system maintenance?

D. Motivation

1) What attitudes are present in the environment that impact CBE?
2) Is the instructor's attitude towards CBE conducive to effective learning?

E. Computer Literacy

1) Is computer literacy promoted?
2) How frequently and/or regularly does the student interact with the computer during the course?

F. Convenience for Students

1) Is the setting comfortable and conducive to learning?
2) Is adequate support (materials, staff assistance) available at user sites?
3) Is the CBE equipment in an accessible location?
4) Is the CBE equipment available at convenient hours?
5) Are there costs involved (usage fees, purchases, travel) in accessing CBE?
4) Are there alternative ways of accessing the CBE materials (modems, mainframes, micro-computers, off campus hook-ups)?
5) Is the equipment available in adequate supply?
6) Does the student save learning time through CBE?

II. Instructional Factors

A. Goals and Objectives

1) Is CAI the appropriate method to meet the course objectives?
2) Has the appropriate type of CAI experience been chosen to meet the course objectives?

B. Content

1) Is the purpose of the CAI well defined?
2) Is the instructional material up to date?
3) Is the content relevant and appropriate for the audience?
4) Does the content have appropriate breadth and depth?
5) Is the material clear and coherent?
6) Is the content stimulating to students?
7) Are knowledge and/or skills generalizable to other substantive areas?
8) Are grammar and spelling correct?
9) Is the level of effort used in CAI in balance with other course expectations?
10) Are learning expectations clearly explained to the student?

C. Format of Program

1) Can students move backward or forward in the text as desired?
2) Is the program length appropriate?
3) Is the length of individual items manageable?
4) Are the instructions for use clear and concise?
5) Is feedback provided to students on item choices?
6) Is the software and hardware user friendly?
7) Are graphics, color, and audio used appropriately to convey course material?

D. Values

1) Is the material free from stereotypical language?
2) Is the material free from sexist, racist, ageist, and other discriminatory biases?

E. Creativity

1) Is creativity reflected in the program?
2) Does the program stimulate creativity in students?
3) Does the program allow for the student to make decisions?
4) Are there open- and/or closed-ended alternatives as responses?

F. Student Attitudes toward Usage

1) Is the learner satisfied overall with the CAI experience?
2) Is the learner satisfied with CAI content?
3) Is the student motivated to learn the material?
4) Is the student's attitude affected by whether the CAI is voluntary or involuntary?

G. Achievement and Learning Outcomes

1) Is student performance measured on increased skill or knowledge?
2) Is long-term retention measured?
3) What learning styles are maximized by the CAI experience?

III. Managerial Factors

A. Record Keeping

1) Does the system allow for comprehensive data collection?
2) Can performance data easily be queried or manipulated?
3) Are there adequate safeguards for confidentiality?

B. Author Support and Utilities

1) Is the program bug free?
2) Are data easily manipulated?
3) Are the programs easily modifiable?
4) Is it possible for the student and instructor to interact with and provide feedback for each other?

C. Evaluation

1) Is the CBE to be evaluated?
2) Who evaluates the CBE component?
3) How will the evaluation take place?

Student Evaluation Instrument for CBE

The following list of scale items has been developed for a potential CBE evaluation questionnaire to be completed by student users. Instructors are encouraged to choose questions that are applicable to their evaluation needs. For clarity, the scale items are formatted into the same categories, as appropriate, which appear in the instructor's criteria for CBE evaluation.

Generic language has been used throughout this instrument as indicated by the statement in the third paragraph of the sample instructions below: "Please indicate the extent to which you used the CAI materials." The instructor might prefer one of these statements: "...the extent to which you used the simulation" or "...the extent to which you used the CAI lessons." The term "CAI" has been used throughout the instrument to refer to any part of the course instruction involving computers.

Please note that all of the items are written in a positive form, such as "I understood the purpose of the CAI materials" rather than "I did not understand the purpose of the CAI materials." Only positive statements were used to prevent confusion or duplication. If the instructor wants to use the split-half technique within the instrument for reliability testing, he or she might prefer to add some comparable items stated in the negative.

The following paragraphs provide sample instructions to potential respondents for evaluating CBE:

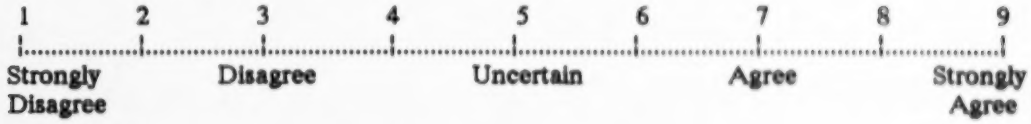
> The information that you provide by responding to the following questions will be used to evaluate the use of CAI in this course. Your identity will not be associated with any report of the findings. You do not need to sign your name.
>
> For each of the following, please circle any point along the line that most accurately reflects your opinion in response to each of the statements. You can locate your mark at any point. Feel free to leave an item blank if you are unable to express an opinion on a particular item. Remember, though, that you can also circle 5 for "Uncertain," if that properly expresses your opinion.
>
> Many of these statements will not likely make any sense to you if you have not used any of the CAI materials. Please indicate the extent to which you used the CAI materials in this class:

1	2	3	4	5	6	7	8	9
Never Did Them		Did about 1/4 of Them		Did about 1/2 of Them		Did about 3/4 of Them		Did All of Them

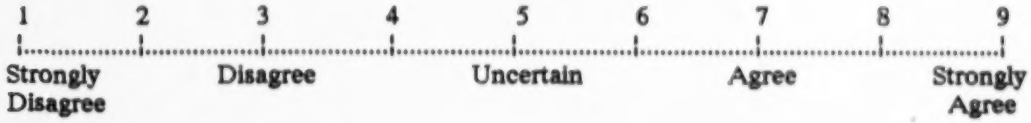
I. Environmental Factors

A. Motivation

1) I was supported by positive attitudes from my peers about CAI.

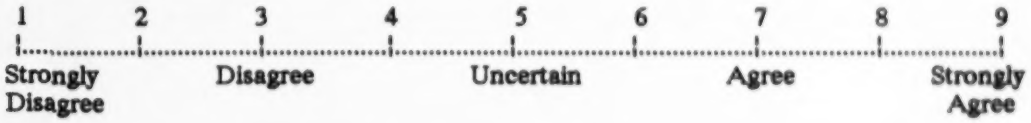


2) The instructor's attitude towards CAI was conducive to effective learning.

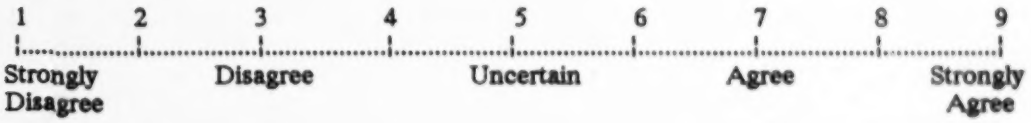


B. Computer Literacy

1) Previous exposure to computers facilitated my ability to do CAI.

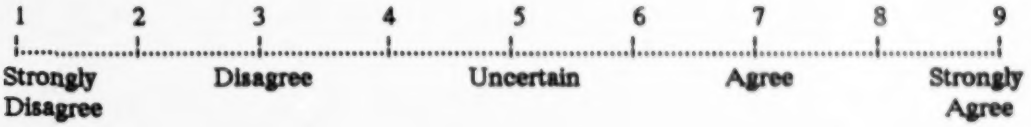


2) The experience with CAI increased my computer literacy.

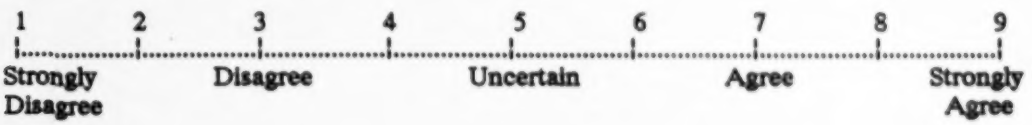


C. Convenience for Students

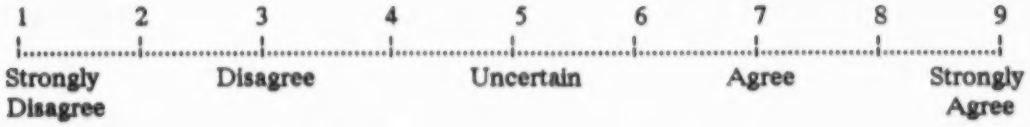
1) The setting was conducive to learning.



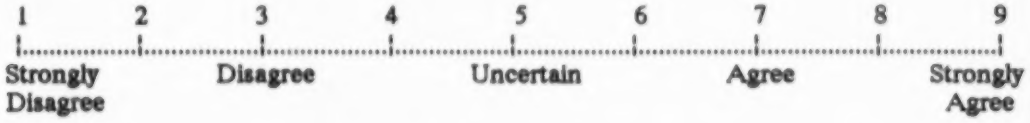
2) Adequate staff assistance was available at user sites.



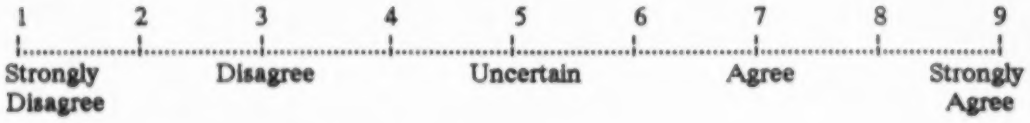
3) Adequate materials (handouts, instructions, documentation, manuals) were provided.



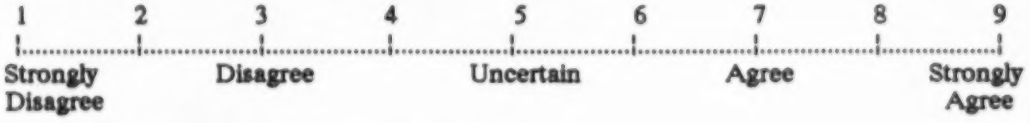
4) The computer equipment was in an accessible location.



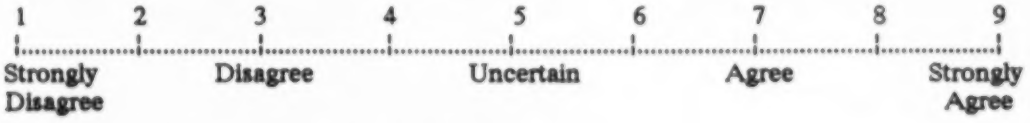
5) The computer equipment was available at convenient hours.



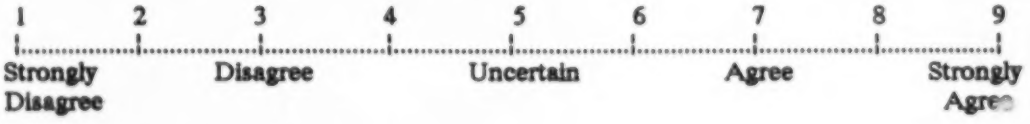
6) My costs involved in accessing CAI were within reason.



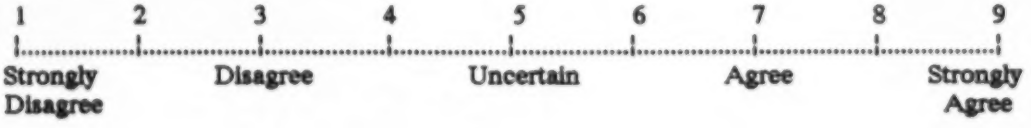
7) There were alternative ways to access CAI materials.



8) The availability of computer terminals was adequate.



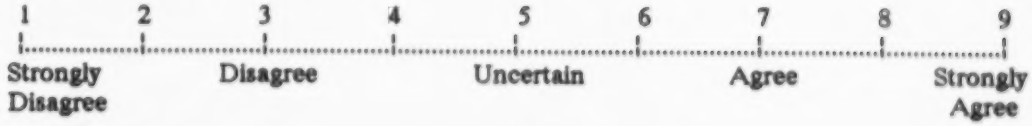
9) CAI decreased my learning time.



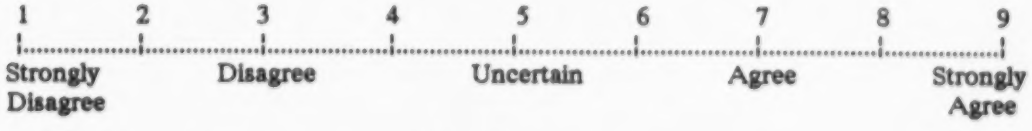
II. Instructional Factors

A. Content

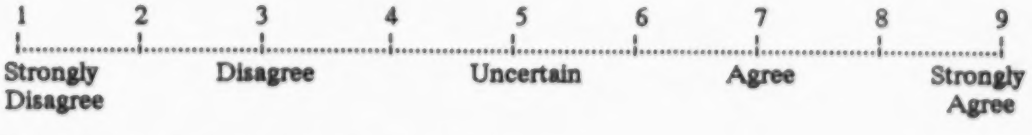
1) I understood the purpose of the CAI.



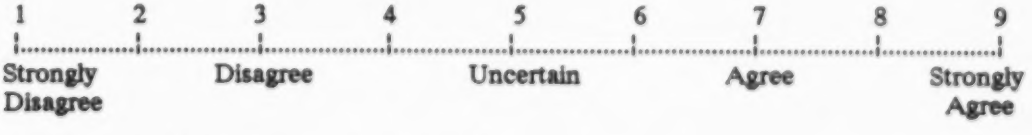
2) The CAI material was current.



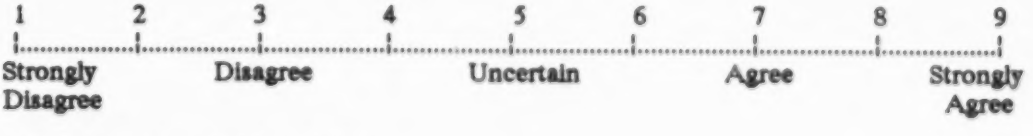
3) The CAI addressed important aspects of the course.



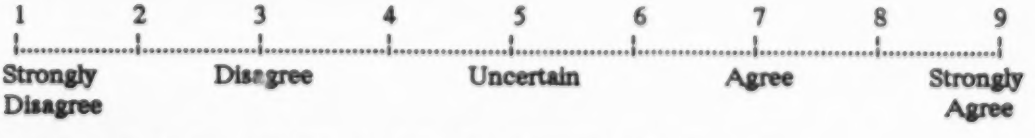
4) The CAI was appropriate for the course level.



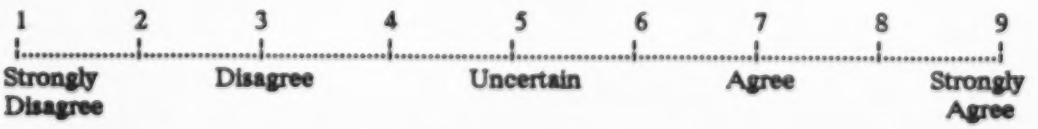
5) The CAI materials were clear and coherent.



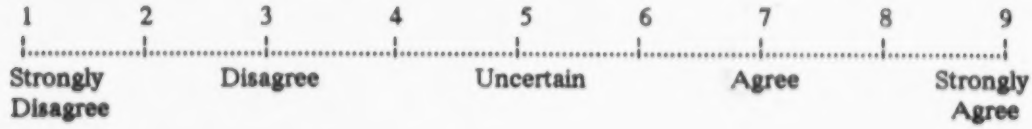
6) The CAI experience held my interest.



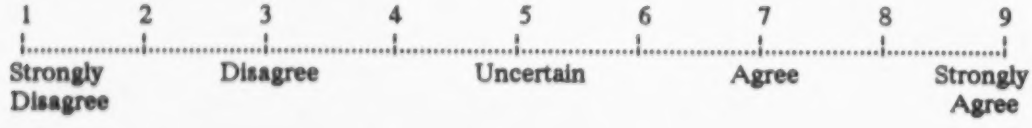
7) The CAI materials provided me with knowledge generalizable to other substantive areas.



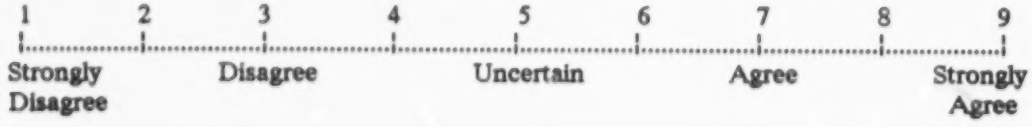
8) The CAI materials provided me with skills generalizable to other substantive areas.



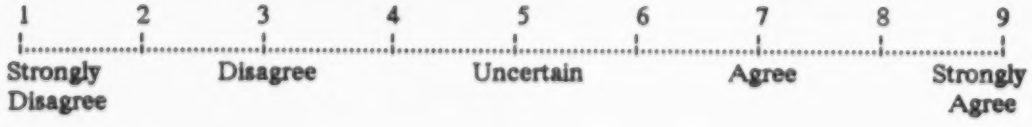
9) Spelling and grammar were correct.



10) The amount of effort required in the CAI materials was in balance with other course expectations.

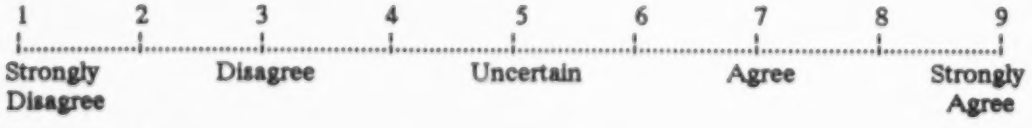


11) I understood the learning expectations for the CAI.

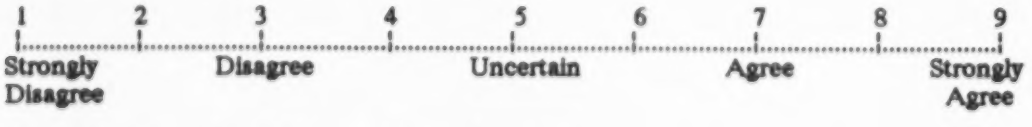


B. Format of Program

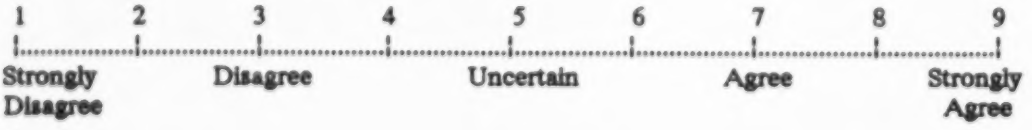
1) It was easy to move about in the CAI material.



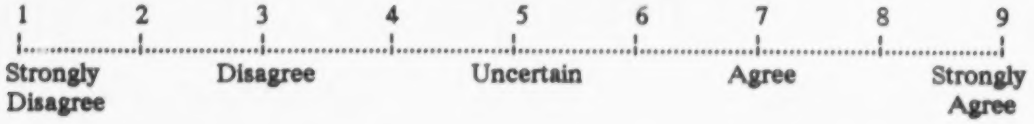
2) The length of the individual items was manageable.



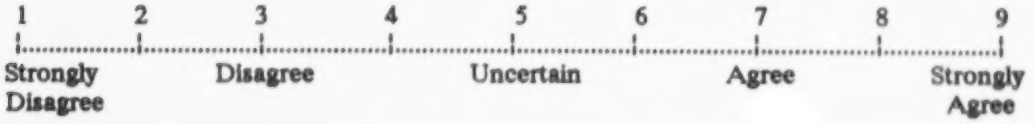
3) The directions for using CAI were clear and concise.



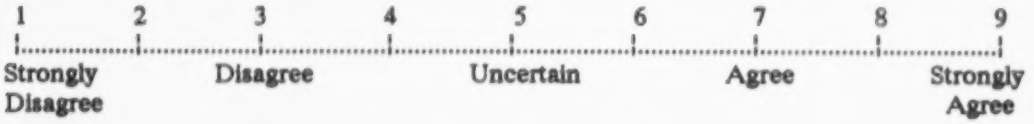
4) Feedback after each response added to my understanding of the CAI.



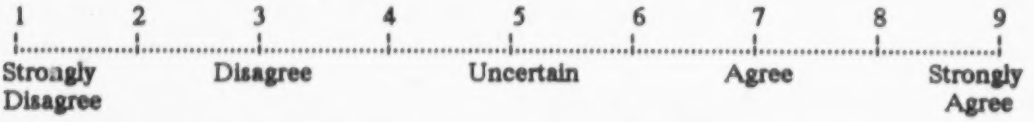
5) The CAI software was user friendly.



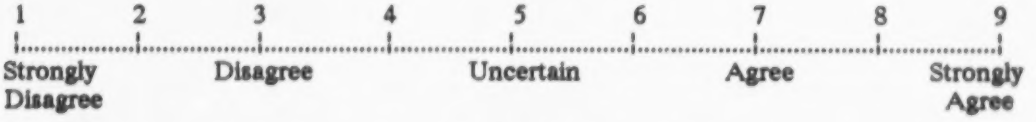
6) The CAI hardware was user friendly.



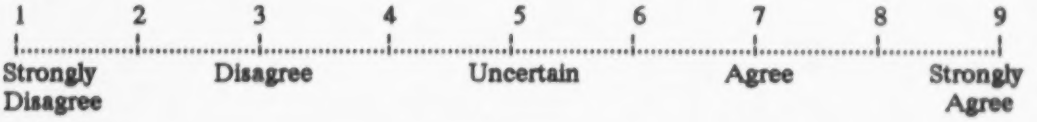
7) The physical layout of the material was attractive.



8) The graphics, color and audio used in the CAI were appropriate.

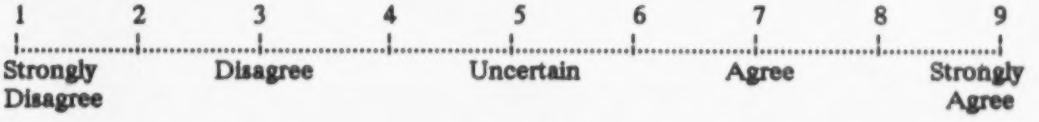


9) I was in control of my progress as I moved through the materials.

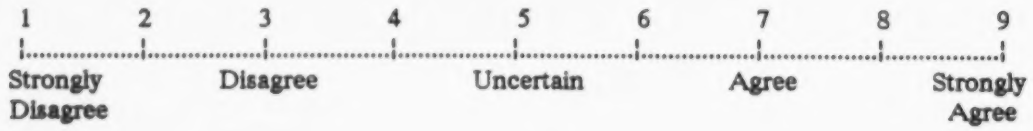


C. Values

1) The CAI materials were free from stereotypical language.

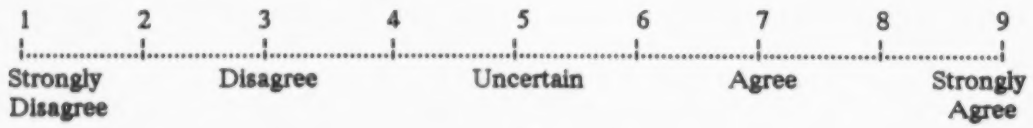


2) The CAI materials were free from sexist, racist, ageist, and other discriminatory biases.

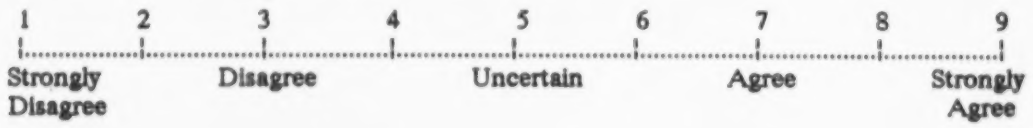


D. Creativity

1) The CAI materials were creatively presented.

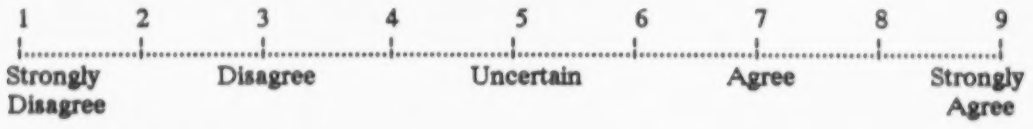


2) The CAI materials allowed me to express my own creativity.

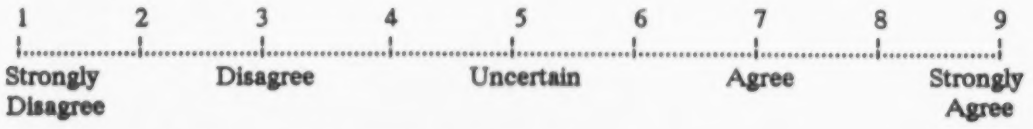


E. Student Attitudes Towards Usage

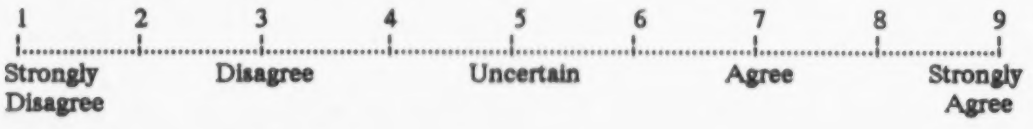
1) I feel positive about using CAI for teaching and learning.



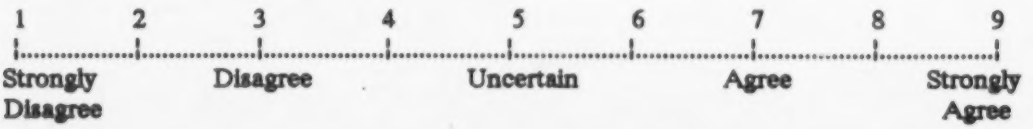
2) I felt motivated to use CAI.



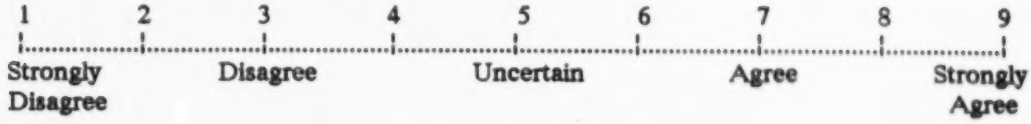
3) It was helpful to have CAI as a course requirement.



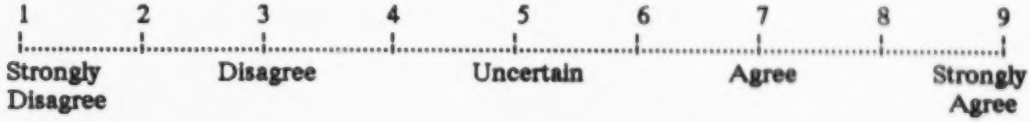
4) My experience with CAI was too impersonal.



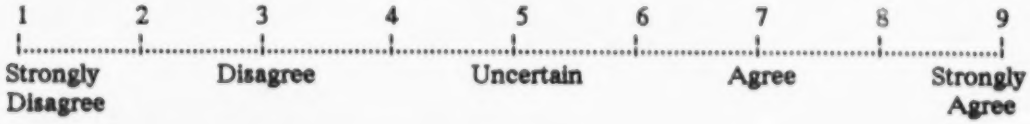
5) The amount of time required to do CAI was appropriate.



6) I would like to use CAI in other courses if it were available.

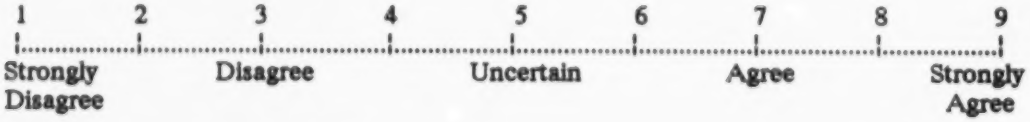


7) I liked the fact that CAI was an individualized alternative to learning.

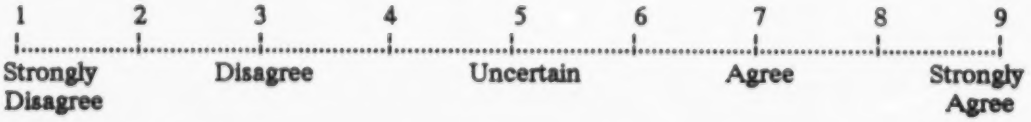


F. Achievement and Learning Outcomes

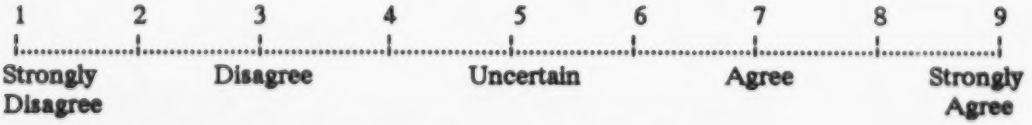
1) My knowledge of the course material was increased by the CAI materials.



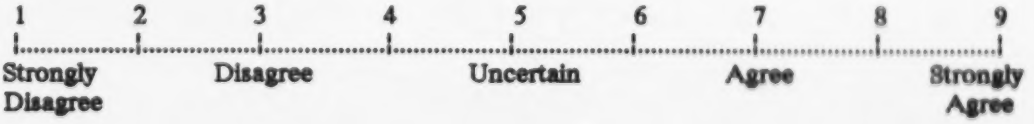
2) CAI helped my performance in this course.



3) The CAI materials helped me comprehend the material from the course readings.

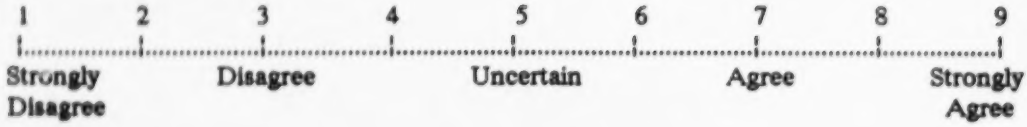


4) The CAI materials helped me comprehend the material from class lectures or discussion.

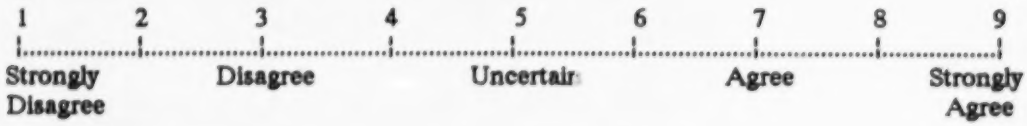


III. Managerial Factors

1) The CAI materials were bug-free.



2) It was helpful to interact with and provide feedback to the instructor.



IV. Open Ended Questions

1) Indicate the approximate amount of time used on CAI materials.

2) How could the CAI experience be improved?

3) Any other comments?

Recommendations

A number of recommendations for computer-based education emerge from this project. The recommendations provided below are intended both as an aid for the instructor in establishing CBE and/or when evaluating CBE materials or curricula. These recommendations speak to the policy and procedural matters for a CBE system and to the data generated by such a system.

Policies

1. A specific plan for the evaluation of particular CBE materials and/or a CBE curriculum should be developed by the responsible academic unit.

2. The commitment and level of effort to evaluate CBE should be equivalent to the evaluation of any other instructional technique.

3. Rewards to the instructor for efforts devoted to CBE should be the same as those for more traditional methods of instruction.

4. Networking with other academic units for purposes of CBE development and support should be encouraged.

5. All responsible parties must assure adequate logistical and financial support for system maintenance.

Procedures

1. The academic unit must assure access to facilities at appropriate and reasonably convenient times and locations.

2. The academic unit must assure access to instructional programs in a timely manner consistent with the instructional purposes of a particular course.

Evaluative Data

1. Data should be gathered on user time on task and/or level of effort required by the user in order to determine utilization by the individual student or groups of student users.

2. Data should be gathered on the performance or achievement of CBE users and, where possible, correlated with other, non-computer-related performance measures.

3. Item analyses or other tests of validity should be performed on all instructional materials where feasible.

This list of recommendations is surely not exhaustive. Additional items will likely emerge in the course of development, implementation, evaluation of CBE.

Summary

This section of the report provides the rationale for identifying what is labeled here as the "EIM Model for Evaluating Computer-Based Education." In support of that choice, a list of 63 evaluative questions for the instructor were developed around the framework of environmental, instructional, and managerial components. That was followed by a listing of 53 potential items for a student-user questionnaire. The section closes with a listing of recommendations pertaining to policy, procedural and data matters.

IMPLICATIONS

CBE in higher education is now a reality. Universities, in order to adequately provide education and information to students, must plan for effective use of computer technologies. As this development continues, CBE will become more prevalent in higher education. The literature has shown that CBE is a positive innovation in the academic environment, though others may challenge this assertion.

Evaluation can be a catalyst to objectify any debate that might exist over the appropriateness of CBE in higher education. The central issues about the propriety of computers in instruction are based on values, not technology. Issues of proper selection of software or hardware or the distribution of computing facilities are certainly important in delivery of CBE. The difficult issues, though, are not satisfied by technical means of evaluation. These issues are concerned with whether any machine is the proper vehicle for instruction and whether CBE is, in and of itself, a proper mode for enhancing human teaching and learning. Nevertheless, evaluation should help us to examine whether important value questions are being dealt with in any particular implementation of CBE. The instruments developed by this project team implicitly and explicitly give expression to some of these value issues. For example, the issues of stereotypical language, discriminatory biases, student control and creativity, and confidentiality are addressed in some of the criteria for evaluation. In yet another example, one student questionnaire item asks if the student felt the CBE experience was too impersonal.

There is an ethical responsibility to evaluate CBE. Not only should evaluation be done, but it should be initiated with a well-developed plan if the evaluation process is to improve the quality of CBE. A comprehensive evaluation system in place at the onset of CBE increases the likelihood that goals and objectives will be linked to the end product. Planning for evaluation enables the instructor to link teaching styles to the learning styles of the student. The EIM model recommended here appears sufficiently inclusive of most aspects of CBE evaluation. The instruments provided above may provoke additional questions relevant to individual concerns.

CBE is no panacea for the problems that currently exist in higher education. One problem is that instructors may invest more time developing CBE programs than preparing material using traditional methods. Universities must appropriately include the time spent in developing and using CBE in its policies and procedures for faculty evaluation. Another problem is the fact that resources for academe are in short supply. Evaluation criteria often express desired conditions; however, those desired CBE systems may not be available due to limited resources. Yet another problem has to do with the variety among students regarding their current computer literacy. Some students find the time invested in accessing computer facilities or learning computer routines to be too demanding. Some of the questions embedded in these problems go to the heart of whether the investment in CBE yields appropriate benefits for institutions, instructors, and student users. Evaluation of CBE will help to identify and understand these problems.

REFERENCES

Albretton, R.L., & Sievert, M. (1988). Investigating the effects of human factors on the outcome of a library computer literacy program. Columbia: University of Missouri. (ERIC Document Reproduction Service No. ED 290 485)

Alessi, S.M., & Trollip, S.R. (1985). Computer-based instruction: Methods and development. Englewood Cliffs, New Jersey: Prentice-Hall.

Austin, M. J., Cox, G., Gottlieb, N., Hawkins, J. D., Kruzich, J. M. & Rauch, R. (1982). Evaluating your agency's programs. Beverly Hills, CA: Sage.

Borich, G. D., & Jemelka, R. P. (1981). Evaluation. In H.F. O'Neil, Jr. (Ed.), Computer-based instruction: A state-of-the-art assessment. New York: Academic Press.

Bracey, G. W. (1987). Computer-assisted instruction: What the research shows. Electronic Learning, 7, 22-23.

Braun, J. A., Jr., & Slobodzian, K. A. (1982). Can computers teach values? Educational Leadership, 39, 508-510.

Caffarella, E. P. (1987). Evaluating the new generation of computer-based instructional software. Educational technology, 27, 19-24.

Coburn, P., Kelman, P., Roberts, N., Snyder, T., Watt, D., Weiner, C. (1982). Practical guide to computers in education. Reading, MA: Addison-Wesley. Coburn, P., Kelman, P., Roberts, N., Snyder, T., Watt, D., Weiner, C. (SecondEd.) (1985). Practical guide to computers in education. Reading, MA: Addison-Wesley.

Dossett, D. & Konczak, L. (1985). New and improved, or just new? Training and Development Journal, 5, 41-44.

Faas, L. A. (1984). The effectiveness of computer-assisted education. In R. A. Camuse (Ed.), Microcomputers in education conference: Literacy plus (pp. 142-148). Rockville, MD: Computer Science Press.

Flynn, J. P. & Kuczeruk, T. (1984). Computer-assisted instruction for the private practitioner. In M. D. Schwartz (Ed.), Using computers in clinical practice (pp. 395-416). New York: Haworth Press.

Flynn, J. P. (1985). MERGE: Computer simulations of social policy process. Computers in Human Service. 1, 33-52.

Flynn, J. P. (1987). Simulating social policy process through electronic mail. Computers in Human Services, 2, 13-26.

Freiherr, G. (1984). Artificial intelligence in psychology and psychiatry. In M.D. Schwartz (Ed.), Using computers in clinical practice: Psychotherapy and mental health applications (pp. 459-466). New York: Haworth Press.

Galagan, P. (1987). Computers and training: Allies or enemies? Training and Development Journal, 41, 73-76.

Grubbs, J. H., Meszkevitz, S. L., & Ennis, C. W. (1986). Integrating the computer into engineering at West Point. Engineering Education, 76, 219-222.

Hartig, G. (1985). Students are capable of assessing the effectiveness of computer-assisted instruction. Indianapolis: Indiana University, Independent Study Program, School of Continuing Studies. (ERIC Document Reproduction Service No. ED 270 098)

Heermann, B. (1988). Teaching and learning with computers: A guide for college faculty and administrators. San Francisco, CA: Jossey-Bass.

Hofstetter, F. T. (1981). Computer-based instruction: Roots, origins, applications, benefits, features, systems, trends and issues. Prepared for the International Sales Meeting of the Digital Equipment Corporation, Jacksonville, Fla.

Holmes, G. (1982). Computer-assisted instruction: A discussion of some of the issues for would-be implementors. Educational Technology, 22, 7-12.

Kearsley, G. (1983). Computer-based training: A guide to selection and implementation. Reading, MA: Addison-Wesley.

Kearsley, G. (1988). Validation of an expert system: The CBT analyst. Journal of Computer-Based Instruction, 15, 61-64.

Kozma, R. B., Bangert-Drowns, R., & Johnston, J. (1987). Rewarding innovation: 1987 EDUCOM/NCRIPTAL higher education software awards. EDUCOM Bulletin, 22, 18-26.

Kulik, J. A., & Kulik, C. C. (1987). Review of recent research literature on computer-based instruction. Contemporary Educational Psychology, 12, 222-230.

Kulik, J. A., & Kulik, C. C. (1986). Effectiveness of computer-based education in colleges. AEDS Journal, 19, 81-108.

Kulik, J. A., Bangert, R. L., & Williams, G. W. (1983). Effects of computer based teaching on secondary school students. Journal of Educational Psychology, 75, 19-26.

Kulik, C. C., & Kulik, J. A. (1988). Effectiveness of computer-based instruction: An updated analysis. Unpublished manuscript. Ann Arbor: The University of Michigan, Center for Research on Learning and Teaching.

Magidson, E. M. (1978). Student assessment of PLATO: What students like and dislike about CAI. Educational Technology, 8, 15-19.

McClung, C. J., Guerriere, J. A., & McClung, K. A., Jr. (1984). Microcomputers for medical professions. New York: Wiley.

McEwing, R. A., & Roth, G. L. (1985). Evaluating CBT evaluation. Training and Development Journal, 39, 32-35.

Northwest Regional Educational Laboratory. (1982). Evaluator's guide for microcomputer-based instructional packages. University of Oregon: International Council for Computers is Education.

Nardone, D. A., Schriner, C. L., Guyer, K. P., & Kositch, L. P. (1987). Use of computer simulation to teach history. Journal of Medical Education, 62, 191-193.

National Commission for Employment Policy. (1986). Computers in the workplace: Selected issues (Report No. 19). Washington, DC: U.S. Department of Education.

National Education Association. (1983). A teacher survey NEA report: Computers in the classroom. National Education Association. Washington, DC: Author.

Norris, D. E., Skilbeck, C. E., Hayward, A. E., & Torpy, D. M. (1985). Microcomputers in clinical practice. New York: Wiley.

Oates, W. (1982). Effects of computer-assisted instruction in writing skills on journalism students in beginning newswriting classes. (Doctoral dissertation, Indiana University). Dissertation Abstracts International, 43, 2822-A.

Office of Technology Assessment. (1988). Power on! New tools for teaching and learning. Washington, DC: Author.

Oliver, J. P. J., & Huxley, P. J. (1988). The development of computer assisted learning (CAL) materials for teaching and testing mental health social work in Great Britain: A review of four years' progress. Journal of Teaching in Social Work, 2, 21-34.

Orlansky, J. (1983). Effectiveness of CAI: A different finding. Electronic Learning, 3, 58-60. Park Row Software. (1987). The CBT analyst [Computer program]. San Diego, CA: Park Row Software.

Piemme, T. E. (1988). Computer-assisted learning and evaluation in medicine. Journal of the American Medical Association, 260, 367-371.

Por, G. (1987, August). Hypermedia and higher education. Computer Currents, 14-16.

Samojiden, E., & Rauch, M. (1982). The use of computers in the classroom. Paper presented at the Minnesota Reading Association Conference, Osseo, Minnesota.

Schwartz. M. D. (Ed.). (1984). Using computers in clinical practice: Psychotherapy and mental health applications. New York: Haworth.

Shafer, D. (1988, May-June). Hypermedia and expert systems: A marriage made in hyper heaven. Hyperage, 26-33.

Smallen, D. L. (1989). Infusing computing into the curriculum: Challenge for the next decade. Academic Computing, 3, 8-12, 32-35.

Stufflebeam, D. L., Foley, W. J., Gephart, W. J., Guba, E. G., Hammond, R. L., Merriman, H. D., & Provus, M. M. (1971). Educational evaluation and decision making. Itasca, IL: Peacock.

Truett, C., & Gillespie, L. (1984). Choosing educational software: A buyer's guide. Littletown, CO: Libraries Unlimited.

Wehrenberg, S. B. (1985). Is the computer the ultimate training tool? Personnel Journal, 64, 95-98.

Yankelovich, N., Haan, B. J., Meyrowitz, N. K., & Drucker, S. M. (1988). Intermedia: The concept and construction of a seamless information environment. IEEE Computer, 21, 81-96.

Yankelovich, N., Meyrowitz, N., van Dam, A. (1985). Reading and writing the electronic book. IEEE Computer, 18, 15-30.

Zemke, R. (1984). Evaluating computer-assisted instruction: The good, the bad and the why. Training, 21, 22-47.

OTHER READINGS

Adams, D. M., & Hamm, M. (1987). Electronic learning: Issues and teaching ideas for educational computing, television, and visual literacy. Springfield, Ill: Charles C. Thomas.

Ambron, S., & Hooper, K. (Eds.) (1988). Interactive multimedia: Visions of multimedia for developers, educators and information providers. Redmond, WA: Microsoft Press.

Austin, D. (1985). Computers. Supervising: Technical aspects of supervision. The choice series #40. A self-learning opportunity. Washington, England: Northern Regional Management Centre. (ERIC Document Reproduction Service No. ED 268 247)

Austin, M. J., Brannon, D., & Pecora, P. J. (1984). Managing staff development programs in human service agencies. Chicago, IL: Nelson-Hall.

Balian, E. S. (1987, March). Teaching critical thinking in the computer-assisted instructional environment. Paper presented at the National Seminar on Successful College Teaching Eleventh National Conference. Orlando, FL.

Beck, R. J., Ellis, L. B. M., Scott, D., Raines, J. R., & Hakanson, N. (1982). Microcomputer as patient educator. American Journal of Hospital Pharmacy, 39, 2105-2108.

Bronson, R. (1983). Computer simulation: What it is and how it's done. Byte, 9, 95-102. Bryan, L. A., Jr. (1986). Supervisors with micros: Trends and training needs. Training and Development Journal, 40, 38-39.

Buckley, E., & Johnson, E. (1983). Pilot project in computer assisted instruction for adult basic education centers. Great Neck, NY: Great Neck Adult Learning Centers. (ERIC Document Reproduction Service No. ED 230 738)

Bullough, R. V., Sr., & Beatty, L. F. (1987). Classroom applications of micro-computers. Columbus, OH: Merrill.

Burkholder, J. N. (1985). An annotated bibliography of the literature dealing with teacher training in the uses of the computer in education. South Bend: Indiana University. (ERIC Document Reproduction Service No. ED 260 696)

Camuse, R. A. (1984). Microcomputers in education conference: Literacy plus. Rockville, MD: Computer Science Press.

Collagon, R. B. (1976). A programming primer. School Science and Mathematics, 76, 381-391. Educational Testing Service. (1988). Teaching teachers about computers: New research explores the in-service programs that work well. ETS Developments. (Available from Educational Testing Service, Rosedale Road, Princeton, NJ. 08541-0001)

Ellis, L. B. M. (1987). Computer-based patient education. Computers in Human Services, 2, 117-130.

Fisher, G. (1983). Where CAI is effective: A summary of the research. Electronic Learning, 3, 82-84.

Flynn, J. P., Dokter, M., Hein, D., Kuczeruk, T., Loftus, K., Manby, J., Matchinsky, P., Monsma, R., Muller, J., & Rutherford, M. (1982). Computer-assisted instruction: A literature review. Urbana/Champaign: University of Illinois School of Social Work Region V Child Welfare Training Center.

Flynn, J. P., Dokter, M., Hein, D., Kuczeruk, T., Loftus, K., Manby, J., Matchinsky, P., Monsma, R., Muller, J., & Rutherford, M. (1982). Computer-assisted instruction as a training methodology for child placement licensing staff. Kalamazoo: Western Michigan University School of Social Work.

Flynn, J. P. (in press). Issues in the introduction of computers and information technology in human services. In R. Reinoehl & T. Hanna (Eds.), Computer literacy in human services. New York: Haworth Press.

Flynn, J. P. (in press). Using the computer to teach and learn social policy: A report from the classroom and the field. In R. Reinoehl & J. Mueller (Eds.), Computer literacy in human services education. New York: Haworth Press.

Frand, J. L. (1987). The microcomputerization of a business school. Los Angeles: University of California Graduate School of Management. (ERIC Document Reproduction Service No. ED 291 264)

Frick, T. W., Polsgrove, L. J., & Rieth, H. J. A special project to develop and implement a computer-based special teacher education and evaluation laboratory. Washington, DC: Department of Education. (ERIC Document Reproduction Service No. ED 292 250)

Gery, R. (1987). Making CBT Happen. Boston: Weingarten.

Goldstein, H., & Fraser, B. S. (1985). Training for work in the computer age: How workers who use computers get their training. Washington, DC: National Commission for Employment Policy.

Gordon, J. (1986). Where the training goes. Training, 23, 49-50, 52-60, 62.

Greist, J. H., Carroll, J. A., Erdman, H. P., Klein, M. H., Wurster, C. R. (Eds.). (1987). Research in mental health computing: The next five years. Computers in Human Services, 2(3/4), 1-176.

Harris, D. (Ed.). (1988). World yearbook of education 1988: Education for the new technologies. New York: Nichols.

Hedlund, J. L., Vieweg, B. W., & Cho, D. W. (1985). Mental health computing in the 1980s: I. General information systems and clinical documentation. Computers in Human Services. 1, 3-33.

Holland, J. (1977). The self-directed search. Palo Alto, CA: Consulting Psychologist Press.

Jelden, D. L. (1985). Effectiveness of computer-based education: The UNC Phoenix system. Greeley, CO: University of Northern Colorado, Educational Technology Center. (ERIC Document Reproduction Service No. ED 270 079)

Johnson, C. S., & Sampson, J. P., Jr. (1985). Training counselors to use computers. Journal of Career Development, 12, 118-128.

Johnson, H., & Churchill, L. D. (1988). A comparison of computer based training versus instructor based training using Micro-Soft Word. University of Washington, Center for Instructional Development and Research. (ERIC Document Reproduction Service No. ED 294 570)

Joiner, L. M., Vensel, G., Ross, J. D., & Silverstein, B. (1982). Microcomputers in education: A nontechnical guide to instructional and school management applications. Holmes Beach, FL: Learning Publications.

Jolly, L. D., & Sisler, G. (1988). Evaluation of computer simulations for teaching apparel merchandising concepts. Home Economics Research Journal, 16, 173-182.

Kulik, J. A., Kulik, C. C., & Bangert-Drowns, R. L. (1985). Effectiveness of computer-based education in secondary schools. Journal of Computer-Based Instruction, 12, 59-68.

Kulik, C. C., Kulik, J. A., & Shwalb, B. J. (1986). The effectiveness of computer-based adult education: A meta-analysis. Journal of Educational Computing Research, 2, 235-252.

Kulik, J. A. (1983). Synthesis of research on computer-based instruction. Educational Leadership, 41, 19-21.

LaMendola, W. F. (1985). The future of human service information technology: An essay on the number 42. Computers in Human Service, 1, 35-50.

Lesgold, A. M. (1984). Human skill in a computerized society: Complex skills and their acquisition. Behavior Research Methods, Instruments and Computers, 16, 79-87.

Lichtman, David. (1979). Survey of educator's attitudes towards computers. Creative Computing, 5, 48-50.

Maidment, R., & Bronstein, R. H. (1973). Simulation games: Design and implementation. Columbus, OH: Chas. E. Merrill.

Mikulecky, L. (1987). The effectiveness of interactive computer assisted modeling in teaching study strategies and concept mapping of college textbook material. Paper presented at the National Reading Conference, St. Petersburg Beach, FL.

Munson, C. E. (1988). Microcomputers in social work education. Computers in Human Services, 3, 143-157.

Nathan, J. (1985). Micromyths: Exploring the limits of learning with computers. Minneapolis, MN: Winston Press.

National Institute of Mental Health. (1987). Research in mental health computer applications: Directions for the future (DHHS Publication No. ADM 87-1468). Washington, DC: U. S. Government Printing Office.

Nesbit, W. A. (1971). Simulation games for the social studies classroom. New York: Foreign Policy Association.

Niemi, J. A., & Gooler, D. D. (Eds.). (1987). Technologies for learning outside the classroom. San Francisco: Jossey Bass.

O'Neil, H. F., Jr. (Ed.). (1981). Computer-based instruction: A state-of-the-art assessment. New York: Academic Press.

Poirot, J. L. (1980). Computers and education. Manchaca, TX: Sterling Swift.

Rusby, N. (Ed.). (1987). Technology based learning: Selected readings. New York: Nichols.

Ryba, K. A., & Chapman, J. (1983). Toward improving learning strategies and personal adjustment with computers. The Computing Teacher, 8, 48-53.

Scardamalia, M., Bereiter, C., McLean, R. S., Swallow, J., & Woodruff, E. (1987). In A. Collins (Chair), Strategies for teaching thinking skills with interactive technologies. Symposium conducted at the meeting of the American Educational Research Association, Washington, DC.

Schloss, P. J., Cartwright, G. P., Smith, M. A., & Polka, B. (1986/87). Effectiveness of computer-assisted special education administration simulations. Journal of Special Education, 20, 503-513.

Smith, J. J. (1987). The effectiveness of a computerized self-help stress coping program with adult males. Computers in Human Services, 2, 37-49.

Suppes, P., & Macken, E. (1978). The historical path from research and development to operational use of CAI. Educational Technology, 18, 9-12.

Taylor, J. B., & Gibbons, J. (1981). Using microcomputers in social agencies. Beverly Hills, CA: Sage Publications.

Trochim, W. M. K., & Davis, J. E. (1986). Computer simulation for program evaluation. Evaluation review, 10, 609-634.

U. S. Office of Personnel Management. (1980). Assessing changes in job behavior due to training: A guide to the participant action plan approach (Publication WPT-1 of the U. S. Office of Personnel Management, Productivity Research and Evaluation Division). Washington, DC: U. S. Government Printing Office.

Weingarten Publications, Inc. (1988). CBT guide 1988: A directory of authoring systems and courseware. Boston, MA: Author.

Willits, S., & Clancy, D. (1984). Computer usage and student performance. AEDS Journal, 18, 87-94.

Wodarski, J. S. (1988). Development of management information systems for human services: A practical guide. Computers in Human Services, 3, 37-49.

Zemke, R. (1984). The information center: Bringing computing to the masses. Training, 21, 48-50, 53.